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## A New Link in the Chain.

Sufficient stress is rarely laid upon the valuable results that may ensue from mutual discussion between people whose interests are distinct and separate yet closely related at some one point. The condition at present prevailing, in which founders and engineers, whose interests are so intimately dovetailed, seldom if ever confer publicly, is as if retailers and customers were to discuss their respective problems in complete isolation.

The value of this kind of link discussion is coming to be more and more widely recognised, and the result is to be seen in the growth of what may be called vertical conferences as distinct from the regulation type of horizontal conference.

An interesting example was afforded not very long ago by a discussion on Patents. The occasion was the conference of the Association of Special Libraries and Information Bureaux, held at Trinity College, Cambridge, and the persons concerned in this particular discussion were all experts vitally concerned with patents, but representative of a wide variety of interests. The instance is an especially valuable one because the case of the industrial man and the patent agent is at least as good as that of the engineer and the founder when the value of mutual discussion is under consideration. There is an Institute of Chartered Patent Agents, which issues its own proceedings, but the average man knows even less of the work of this body than he knows of the work of the engineering and metallurgical institutions. For points are constantly cropping up on which those engaged in industry would like enlightenment from the patent experts, although they do not necessarily fall within the scope of formal consultation with a patent agent.

Obviously the advantages of such discussion, if it is to be cordially supported, would need to be mutual, but in the present case we believe this most certainly to be so. For the peculiar training and experience of the patent agent enables him to broaden himself by every contact with industrial men. The same would apply to the numerous officers engaged at the Patent Office.

The conference in question dealt with patent classification, and of all forms of classification surely this is the most difficult. The ebullitions of the inventor's fancy are so varied and curious that no predetermined scheme can provide for all contingencies. British patents at present are grouped in 271 classes, but any man interested in patents is lucky if he finds his requirements clearly covered by any one of these groups, or, conversely, fails to find in his own group a mass of irrelevant material. That the divisions of technical responsibility in industry are not co-extensive with their own classification is hardly the fault of the Patent Office, which may fairly be regarded as one of the most approachable and effective of the Government Departments in London with which the average industrial man is likely to come in contact.

On this occasion both the Patent Office librarian and a former assistant controller contributed statements, and statements were also obtained from the German and the United States Patent Offices.

The value of the resulting discussion was such as to surprise even the professional experts who took part. Here at least is one practical example of the new type of discussion, that serves as a link between parties whose interests are in the form of a chain. Further developments and experiments in the same direction will be watched with interest.

## Cores.

Because we have what the Americans call a "hunch" that in the future moulding will consist very largely of assembling cores, we would draw readers' attention to Mr. West's Paper on this subject printed elsewhere in this issue. Because almost revolutionary progress was made by the introduction of oil sand cores, perhaps some thought that perfection had been reached. Many of the proprietary brands of oils have commanded and deserved much success because they provided a material stronger in the green bond state than was obtainable by the normal domestic method of preparing linseed oil. It thus became evident that there was room for research, and it appears that as a result of Mr. West's researches a better material will be available for the industry. Obviously it is impossible for the smaller foundries to convert themselves into core-oil factories, and even the larger ones would be well advised to hand over the making of their mixtures to reputable suppliers. As the latter handle large quantities they are in a better position to buy favourably and to specification. They, too, possess specialised plant for mixing. They are, or should be, cognisant of all research carried on in the field which they cover. On the other hand, foundry managers must, *force majeure*, devote both time and thought to research, but they have sufficient manufacturing problems without adding extraneous subjects. Mr. Lake has reported that American foundry owners are shedding the responsibility of manufacturing patterns, this work being left to specialists who will often guarantee the output when moulded in standard moulding machines. Thus our advice is clear cut. The onus of research upon core agglomerants is the dual responsibility of the manufacturers and users, but its actual preparation should be left to the suppliers. Unfortunately, not every foundry is so broad-minded as the Leyland concern, and when they do discover an excellent core compound they keep it secret, and so what should benefit the industry is lost as time passes, something superior is discovered and the discovery dies a natural death, with no honour and little regret.

[The negative on line 5 of the first leader of last week was a printer's error.—EDITOR.]

# Aluminium Cast Irons.

By Arthur B. Everest, Ph.D.

In a previous article * the author has described an investigation into the fundamental influence of aluminium on a pure white iron. It is shown that small additions of aluminium act like silicon in rendering the iron grey, although its greying action is not so marked as that of silicon. Additions of aluminium above 5 per cent. introduce a hard brittle phase into the metal which becomes predominant at about 15 per cent., the first graphitic range terminating at about 8 per cent. of aluminium. Additions of aluminium between 20 and 26 per cent. produce irons in a second graphitic range, having limited machinability.

In the present article grey cast iron formed by the addition of aluminium to low-silicon irons is described. It was felt that such irons, in which the normal silicon content was partly or completely replaced by aluminium, might show useful properties, especially in regard to resistance to growth and oxidation effects under high or fluctuating temperature, and to resistance to corrosion.

In the first place a number of mechanical tests were made on alloys formed by adding aluminium to American washed iron, the aluminium contents being chosen at suitable intervals over the graphite range mentioned above. These tests were intended to indicate the best composition of alloy for further investigation.

### Method of Handling the Alloys.

Alloys were made up, as indicated in the previous article, by adding the aluminium in the molten condition to the crucible melt of iron just before pouring; previous to pouring the metal was stirred and skimmed. Initially no special moulding precautions were taken and long round test bars were poured from the top, the mould being tilted to an angle of about 20 deg. from the horizontal. It was soon realised that this method of casting was unsatisfactory, unsound bars were obtained containing many inclusions of alumina and skin. This confirms the remarks found in the leading article of THE FOUNDRY TRADE JOURNAL, March 29, 1923:—"At one time aluminium was regarded as a 'cure all' in the manufacture of steel, but later, owing to extravagant additions by inefficient melters, it received a bad name. It was found that under the microscope non-metallic inclusions were found existing no doubt in the form of alumina. . . . In cast iron, as far as can be visualised at the moment, 0.03 per cent. of aluminium is beneficial, and 0.25 per cent. detrimental because of these non-metallic inclusions."

Added to this it has been the author's experience that when aluminium cast iron is poured, a leathery oxide skin forms on the surfaces of the stream and heads of the molten metal, and this skin often breaks up and pieces are carried into the casting where they ultimately appear as folded planes of unsoundness.

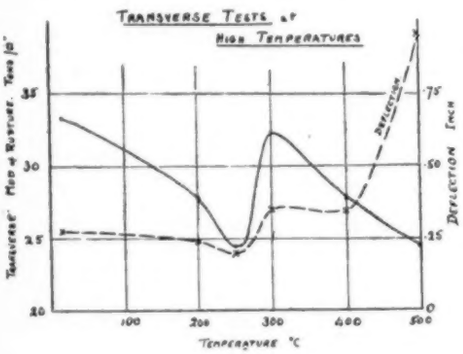


FIG. 1.

After some experience it was found possible to cast good sound test bars of aluminium cast iron by casting the bars vertically and running them from the bottom (three or four bars being fed from one runner). A large feeding basin was provided at the top of the runner, and a steady pouring rate was maintained. The usual test bar cast was the I.B.F. bar "M" (21 in. long × 1.2 in. dia.); large feeding heads were provided at the top end of each bar.

It should be emphasised also that the iron must be hot enough to be well fluid, in order that any alumina formed on the addition of the aluminium may rise freely in the metal and be skimmed off. It was not found necessary to use any flux. In the work described below the iron was usually at a temperature of 1,350 deg. C when the aluminium was added.

### Test Results.

The results of the mechanical tests on the alloys in the first graphitic range are summarised in Table I; in this table the analytical results for aluminium and combined carbon are given. The total carbon is approximately 3.35 per cent. throughout the series and the analyses of other elements show that they are present in negligible quantities (Si, 0.02-0.04; S, 0.04; P, 0.03; and Mn, nil per cent.).

These test results call for little comment, all the bars showed grey fractures, and were all machinable (with slight difficulty in the case of bars No. 7).

A study of these results indicates that the best properties are shown by the irons containing 3 to 4 per cent. of aluminium; accordingly the alloy containing 3.7 per cent. of aluminium was selected for further examination as a typical aluminium cast iron. The properties of this alloy when tested cold are given in Table I.

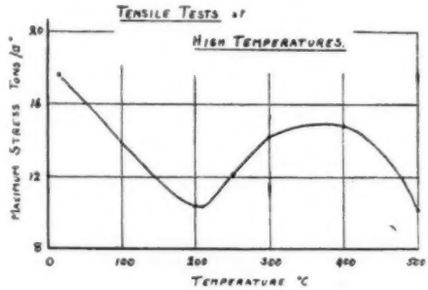


FIG. 2.

### The Properties of Aluminium Cast Iron at Elevated Temperatures.

One of the most important requirements of a modern high quality iron is that not only should it show good properties at normal temperatures, but that it should retain them as far as possible at the more elevated temperatures met in engineering practice; this implies particularly that it should resist constitutional change and resulting growth at these temperatures.

Accordingly, in this study of an aluminium cast iron special attention has been given to its properties under the influence of heat. In the first place, a series of mechanical tests were performed at temperatures varying over the range of room temperature up to 500 deg. C., a fresh bar in the "as cast" condition being used for each transverse and tensile test. The author's best thanks are due to Mr. W. B. Parker, of the British Thomson-Houston Co., Ltd., Rugby, for facilities for carrying out these tests.

The bars in the transverse test were heated by two electrical resistance furnaces, built to go on either side of a central loading shackle. The temperature of the bar was recorded by a thermocouple on the upper side of the bar. The variation in the modulus of rupture and in the deflection of the test bar at the breaking load are shown graphically in Fig. 1. At about 250 deg. C. the curve shows a marked drop, though the iron still retains a good strength. At about 300 deg. C., however, the bars appear to have recovered and show a strength almost as high as that given at room temperature. Above 300 deg. C. strength begins to fall off again, and at 500 deg. C. the deflection curve shows that the bars have reached a plastic condition. The bars tested at this temperature showed marked permanent bending after test. The tests show that the highest safe working temperature would be 400 deg. C.

In Fig. 2 the results of the tensile tests on bars machined to 0.798 in. dia. are shown. The bars in these tests were heated directly by alternating current. The curve is seen to have approximately the same form as the curve connecting transverse strength with temperature. Ordinary irons in high temperature test often show a drop in strength at about 200 or 250 deg. C.,* but in the present work the drop shown is greatly in excess of these ordinary figures. This phenomenon may be attributable to the high combined carbon in the iron (this being about 1.26 per cent.), or it may be directly due to the presence of aluminium. In support of the former suggestion, it may be pointed out that in dilatation test a marked change in the coefficient of expansion is shown at 240 deg. C., the transition temperature of $a-\beta$ carbide.

A thermal expansion curve was drawn for this alloy, in a sensitive dilatometer. It has already been mentioned that a change in the rate of expansion was noted at about 240 deg. C, connected possibly with the $a-\beta$ change in the cementite. The thermal coefficient recorded below this temperature was $11 \times 10^{-6}$, and above it was $15 \times 10^{-6}$. This latter coefficient held, up to about 670 deg. C. Above this temperature an irregular coefficient was obtained, corresponding to the critical range of the iron, until at 800 deg. C. violent growth set in, the expansion of the bar rapidly exceeding the limits of measurement of the apparatus. Subsequent examination of the specimen revealed the fact that it had decomposed completely to graphite and ferrite.

In a repeat test on a smaller specimen in a different apparatus, where the heating rate was higher than in the apparatus used for the former test, no growth was recorded on heating up to 900 deg. C., but on cooling, similar growth to that mentioned above set in at 700 deg. C., and the specimen was again completely decomposed.

In a further test, specimens were annealed by heating them for one hour at various temperatures between 650 and 850 deg. C., a fresh specimen being used at each temperature. The Brinell hardness of the annealed specimens is given in Table II.

Micro examination of the specimens confirms the fact indicated by these figures that decomposition occurs with maximum rapidity between 650 and 750 deg. C.

These tests clearly indicate that aluminium irons, like high silicon irons, are unstable on

TABLE I.—*Mechanical Properties of a Series of Cast Irons containing Aluminium.*

| Bar. | Al. % | C.C. % | Trans. mod. of rupture tons per sq. in. | Tensile strength tons per sq. in. | Crushing strength tons per sq. in. | Brinell hardness. |
|---|---|---|---|---|---|---|
| 1 | 1.05 | 1.84 | 25.25 | 13.88 | 66.17 | 253 |
| 2 | 1.48 | 1.30 | 30.10 | 14.80 | 56.0 | 220 |
| 3 | 2.44 | 1.29 | 34.25 | 10.90 | 56.3 | 220 |
| 4 | 3.18 | 1.54 | 32.0 | 13.90 | 53.82 | 227 |
| 5 | 3.70 | 1.26 | 33.3 | 17.60 | 57.00 | 222 |
| 6 | 5.41 | 1.41 | 32.2 | 16.0 | 57.3 | 252 |
| 7 | 7.02 | 1.76 | 29.35 | 12.8 | 60.49 | 246 |

* "The Influence of Aluminium on an Iron Carbon Alloy." "Foundry Trade Journal," August 25, 1927, p. 169.

* J. W. Donaldson. "Low Temperature Heat Treatment of Special Cast Irons." "Foundry Trade Journal," June 18, 1925, p. 517.

heating and consequently of themselves would be unsuitable for use when subjected to high temperatures. It may be argued that growth normally takes place when the specimens are subjected to fluctuating temperatures below the critical range under conditions very different from those found in the above tests, but the author believes that decomposition in the critical range under these conditions is a definite criterion of the tendency of the iron to grow at temperatures below the critical range.

TABLE II.—*Brinell Hardness after annealing at increasing temperatures.*

| Temp. of anneal. | Brinell hardness. |
|---|---|
| As cast. | 222 |
| 650°C. | 207 |
| 750°C. | 107 |
| 800°C. | 95 |
| 850°C. | 86 |

It is evident that aluminium acts to render the carbide in the iron unstable. In comparative tests, using various alloying elements, Sawamura * confirmed this, but found that the action of aluminium in this direction was not so marked as that of silicon, although more marked than that of nickel, which was also shown to render the carbide unstable at higher temperatures. It was decided to add 0.5 per cent. of chromium to the aluminium iron employed in the above tests in order to render the iron more stable at elevated temperatures.

### Aluminium-Chrome Cast Iron.

Chromium was added as finely crushed 60 per cent. ferro chrome to the crucible of metal; it was found that some 10 or 15 min. were required for complete solution of the chromium. Table III gives the chemical analyses of two casts (66 and 67), containing chromium and Table IV gives the results of mechanical tests on one of these casts.

TABLE III.—*Composition of Al.-Cr. Test Bars.*

| | 66 | 67 |
|---|---|---|
| T.C. .. .. | 3.20 | 3.21 |
| C.C. .. .. | 1.35 | 1.34 |
| Gr. .. .. | 1.85 | 1.87 |
| Si. .. .. | 0.03 | — |
| Mn. .. .. | Trace | — |
| S. .. .. | 0.033 | — |
| P. .. .. | 0.020 | — |
| Cr. .. .. | 0.47 | 0.32 |
| Al. .. .. | 3.81 | 3.61 |

TABLE IV.—*Mechanical Tests given by Sample No.* 67.

| | 671 | 672 | 673 |
|---|---|---|---|
| Transverse max. stress, lbs. | 2,722 | 2,616 | 2,950 |
| Deflection at max. stress, ins. | 0.258 | 0.266 | 0.260 |
| Modulus of rupture, tons per per sq. in. .. .. | 32.55 | 30.97 | 34.95 |
| Tensile strength, tons per sq. in. .. .. .. | 13.15 | 17.84 | 14.14 |

Impact tests were carried out on a Krupp Stanton machine, and indicated that this iron has a very good resistance to repeated impact. With a Brinell hardness figure of 238 the iron was readily machinable and took on a very good finish, also good resistance to abrasion was indicated. The shrinkage of the iron (by Keeps test) was 0.156 in. per ft., the specific gravity 7.015, and the chill indicated by Keeps test was 0.03 inch.

Micro examination revealed a very fine graphite form, in a completely pearlitic matrix, with only slight signs of carbide crystals. It may be mentioned that throughout these experiments it was found that aluminium gave a finer graphite form than was found in the corresponding silicon irons.

In order to study the influence of heat on this alloy a dilatometric analysis was performed. It was found that on heating the metal up to 900 deg. C. and cooling no marked growth took place. The thermal expansion up to 220 deg. C. was slightly lower than normal, the coefficient being $10.8 \times 10^{-6}$. Beyond this point, up to 680 deg. C., regular expansion was obtained with a coefficient of $13.7 \times 10^{-6}$. Above this the co-efficient was irregular. These results show that 0.5 per cent. of chromium has a marked stabilising effect on the 3.7 per cent. aluminium iron.

A bar was annealed at 800 deg. C. for one hour and slowly cooled—a drastic test on cast iron, but the comparison of the micro-structure after annealing with that of the alloy without chromium, annealed for 30 minutes at the same temperature, showed the stabilising effect of the chromium; the former showing a pearlitic structure partially decomposed and the latter nothing but ferrite and graphite: the Brinell hardness of the two annealed pieces was 170 and 80 respectively.

Besides the stabilising action of the chromium, it is seen that it has had a slight hardening action without impairing the good mechanical properties of the original alloy.

### Aluminium-Chromium Cast Iron with Low Silicon.

The alloy containing 3.7 per cent. aluminium and 0.5 per cent. chromium only resembles cast iron in so far as its total carbon content is concerned. It was therefore felt desirable to test an alloy containing aluminium and chromium together with silicon, manganese, sulphur and phosphorus, as would be found in a special high quality iron for engineering purposes. Table V gives the analysis of the original washed iron, and that of Mayari pig iron used for the preparing of the new alloy. Column 4 gives the desired composition, it being considered necessary to increase the chromium over 0.5 per cent. on account of the presence of nickel in the Mayari. As a preliminary test aluminium was added to the base shown in column 5, made up of equal parts of washed iron and Mayari, with the results shown in column 6. This contained a higher quantity of total carbon than was expected after the addition of aluminium, and accordingly cast 91 was repeated with the addition of steel scrap to bring down total carbon. The composition aimed at in the base was total carbon 2.8 per cent., chromium 0.75 per cent. Column 7 gives the new base as calculated, and column 8 the actual analysis of the new cast 93, after the addition of 3.7 per cent. of aluminium. The base was made up of Mayari iron 40 per cent., American washed iron 30 per cent., and steel scrap 30 per cent., melted down together, aluminium being added as before.

TABLE V.—*Composition details of an Al. Si. Cr. Ni. Cast Iron.*

| 1 | Amer. washed iron. 2 | Mayari pig. 3 | Base. Calculated. 4 | Base. Test 90. 5 | Cast 91. 6 | Calculated base. 7 | Cast 93. 8 |
|---|---|---|---|---|---|---|---|
| T.C. .. .. | 3.5 | 4.32 | 3.91 | 3.80 | 3.55 | 2.83 | 2.90 |
| C.C. .. .. | 3.5 | 2.68 | — | 3.80 | 1.25 | — | 1.08 |
| Gr. .. .. | Trace | 1.55 | — | Nil | 2.30 | — | 1.82 |
| Si. .. .. | 0.029 | 1.45 | 0.74 | 0.41 | 0.40 | 0.58 | 0.45 |
| Mn. .. .. | Trace | 1.28 | 0.64 | 0.53 | 0.52 | 0.51 | 0.62 |
| S. .. .. | 0.028 | 0.012 | 0.02 | 0.022 | 0.026 | 0.02 | 0.048 |
| P. .. .. | 0.016 | 0.078 | 0.05 | 0.053 | 0.049 | approx. 0.04 | 0.090 |
| Ni. .. .. | — | 0.89 | 0.45 | 0.49 | 0.47 | approx. 0.356 | 0.33 |
| Cr. .. .. | — | 1.92 | 0.96 | 1.03 | 0.98 | 0.77 | 0.66 |
| Al. .. .. | — | — | — | — | 3.84 | 3.7 added | 4.10 |

TABLE VI.—*Transverse and Tensile Tests of the Alloy shown in Table V.*

| Cast No. .. .. .. .. .. .. | 91 | | | 93 | | |
|---|---|---|---|---|---|---|
| Bar No. .. .. .. .. .. .. | 3 | 4 | 5 | 2 | 3 | 4* |
| Transverse max. stress, lbs. (Corrected to 1.2 in. dia.).. .. .. .. .. | 3,180 | 3,002 | 3,135 | 3,062 | 2,900 | (3,292) |
| Deflection at max. Stress Ins. .. .. | 0.290 | 0.260 | 0.277 | 0.263 | 0.227 | (0.180) |
| Modulus of rupture. Tons per sq. in... .. | 37.65 | 35.56 | 37.15 | 36.25 | 34.35 | 34.63 |
| Tensile strength. Tons per sq. in. .. .. | 15.12 | 17.24 | — | 16.52 | 17.35 | — |

* Bar tested on 16 in. span.

### Test Results

The iron from each cast showed a dense close-grained fracture, and casting skin was good. The metal in machining was harder than ordinary cast iron, but it machined freely and gave a good finish. The chill test showed 0.03-in. depth of chill. Table VI shows the transverse and tensile test results.

Very good resistance to repeated impact was shown by this iron in the Stanton test. The mean Brinell hardness number was 250. Micro examination showed fine curved flakes of graphite in a pearlitic ground mass. The structure is similar to that of the plain aluminium and aluminium-chromium alloys, but shows a smaller grain size.

From 0 to 200 deg. C. the co-efficient of thermal expansion was $11 \times 10^{-6}$, and from 250 to 540 deg. C. was $13.6 \times 10^{-6}$. The permanent growth was 0.17 per cent. after one heating to 935 deg. C. The test shows that the iron has a slightly lower co-efficient than normal, and appears to be quite stable, the permanent growth being small.

Annealing was carried out for one hour at 800 deg. C. followed by slow cooling, and it was shown by micro examination that the stability is much the same as that of the aluminium-chrome alloy described above.

Corrosion tests performed on the various aluminium and aluminium-chrome cast irons, by immersing them under standard conditions in sulphuric acid of various strengths, show that these irons have no special resistance to attack by the acid employed, as compared with ordinary iron.

Experimental work was performed on the alloys in what has been described in the previous article as the second graphitic range (18 per cent. to 25 per cent. of aluminium). However, it was found that these alloys were so unstable thermally that they decomposed on cooling except in castings of very thin section. In this latter case alloys disintegrated in the atmosphere owing to the action of moisture on the aluminium carbide present.

When these alloys were stabilised by the addition of chromium, they became so hard as to be quite unmachinable and unworkable. Consequently, no further work has been performed on this special range of alloys.

### Conclusions.

Years of work would be required to investigate all the various possibilities of the employment of a metal like aluminium as a useful addition to cast iron, and the author does not claim that the investigation reported in these two articles has been in any way exhaustive; but as far as it has gone it would appear to indicate that at the moment there is no definite future for aluminium cast iron for normal purposes, for although such iron has been shown to have good properties (it must be

* Sawamura. Mem. of Coll. Eng. Kyoto Imp. Univ., Vol. 4, No. 4, 1926.

remembered, however, that high quality base materials have been used throughout the work), nevertheless, no special properties have been shown which cannot be obtained by other simpler and better methods of treating cast iron (control of composition, etc.), and, moreover, aluminium iron shows special casting difficulties, which have to be overcome if sound, clean castings free from alumina inclusions are to be obtained.

At some future date, when the technique of cast iron is more fully understood, it may be that aluminium cast iron will come into use on account of some special virtue not yet revealed, but at the moment, this time does not appear to be in sight.

Finally, the author wishes to thank Mr. J. G. Pearce, Director of the British Cast Iron Research Association, for permission to publish these results, and to thank Professor Turner, late of the University of Birmingham, for his interest and assistance in the work.

## The Structure of Cast Iron.

There was a well-attended meeting of the Birmingham, Coventry and West Midlands Branch of the Institute of British Foundrymen at the Engineers' Club, Waterloo Street, Birmingham, on December 8, to hear an address on "The Structure of Cast Iron." The speaker was Professor D. Hanson, the successor of Professor Turner in the Department of Metallurgy at the University of Birmingham.

MR. F. G. STARR, Branch-President, offered Dr. Hanson a hearty welcome, both in his professorial capacity, and as a member of the Branch. He recalled the pleasant relations existing between Professor Turner and the Branch, expressing a hope that there would be an equally close and valuable association with Dr. Hanson.

PROFESSOR HANSON said he proposed to talk about cast iron, not primarily in relation to its practical use, but rather in relation to current theories put forward to explain its structure. That was not to say, however, that what he had to say had no bearing on practical matters. It was scarcely necessary to call attention to the complicated nature of cast iron. Those who were working with it every day knew that it was full of tricks, and that it was one of the most complicated metallic alloys with which any metallurgist had to deal. Industrial cast irons contained five or six variables, and sometimes considerably more. It was, perhaps, not to be wondered at, therefore, that the varying structures found in it were also complicated. They were accustomed in their dealings with metallic alloys to consider their structures in relation to what was called the phase rule, and he would show one or two slides representing diagrams by means of which they illustrated the structure of metals. The phase rule was rather despised by some metallurgists because they considered that although it would be a theoretical rule it had little relation with practical matters. The phase rule only referred to the condition of alloys when they were in a state of equilibrium. The behaviour of alloys was always controlled by the equilibrium state, because that was the state which they were trying to attain, and to which, under suitable conditions, they would attain. For that reason their behaviour could always be referred to diagrams based on the phase rule. He had had much experience in investigating alloys in relation to the phase rule, and he had yet to find a case in which the different constituents found in the structure of metallic alloys could not be adequately represented by the phase diagram when they were allowed to attain a state of equilibrium. He suggested that if they were to develop the theory of any alloy and utilise that theory to help practical methods, it was necessary for the practical man and the man of theory to get together and exchange views.

Having shown and explained a number of slides, Professor Hanson said the new theory considered equilibrium conditions in cast iron from the standpoint of ternary alloys. It bridged the gap between cast iron and steel, making both part of one complete theory. It accounted for the carbide stability in low-carbon and low-silicon alloys, and for the graphite stability in high-carbon and high-silicon alloys, and for the stability of the two forms in the intermediate range of composition. Further, it accounted for the graphitising influence of high-carbon content. Although a single diagram was used to represent equilibrium conditions, the double diagram theory was not entirely displaced, and might be retained as a logical extension of the theory to account for the effects of rapid cooling. Next, it offered a ready explanation of the effects of other elements on cast iron, and, lastly, the theory did not exclude the theory of graphite formation in high-carbon steels.

DR. NORBURY (B.C.I.R.A.), while granting that the theory explained many things, thought there were quite a number it did not explain.

MR. F. G. COOK said though the evidence was not conclusive the work was sufficiently significant to be of world-wide importance, and was the first step in the direction of obtaining a clearer conception as to what took place in cast irons. In the decomposition of the compounds one wanted to know what became of the silicon. No trace of it was seen in the structures. Another point that might be settled by the work was as to whether graphite existed when the metal was in a molten state.

PROFESSOR HANSON, answering the point as to what became of the silicon, said it was dissolved in the other constituents of the cast iron—or combined. He did not know how much went to the ferrite, and how much to the carbide; some might even go to the graphite. If it were not dissolved in the other constituents, and if it occurred as a separate phase, they would not get both graphite and carbide existing together, because the theoretical laws said they might only have three substances present. He could not answer the question as to what was the state of carbon in the liquid form, because he did not get any evidence bearing on the point. He believed there was room for a great deal of investigation into the nature of carbon in molten iron. He was not at present convinced that heat treatment in the liquid state altered the final equilibrium in the solid state. It could alter the form of graphite, for example, but whether it altered the total amount of graphite they got in the fully annealed iron he did not know.

A hearty vote of thanks was accorded to Professor Hanson.

## American Exchange Paper Authors.

Mr. John Howe Hall, metallurgist, Taylor Wharton Iron & Steel Company, High Bridge, N.J., and Mr. H. A. Schwartz, director of research, National Malleable & Steel Castings Company, Cleveland, have been chosen by the American Foundrymen's Association to present two of the American Foundrymen's Association Exchange Papers before 1928 meetings of the European foundry associations.

Mr. Hall will present the Exchange Paper before the next annual meeting of the Institute of British Foundrymen, to be held at Leicester, and Mr. Schwartz the Paper before the meeting of the Association Technique de Fonderie de France.

John W. Bolton, metallurgist for the Lunkenheimer Company, Cincinnati, has been chosen to present the 1929 A.F.A. Exchange Paper before the Institute of British Foundrymen. The 1929 meeting of the Institute of British Foundrymen will be the third international foundry congress, the first being held in Paris in 1923 and the second in Detroit in 1926.

**Australian Iron and Steel Bounty.**—A cable from Canberra states that the Australian Minister for Trade and Customs, moving, in the House of Representatives, the second reading of the Iron and Steel Products Bounty Act Amendment Bill, said that the Bill proposed to increase the iron bounty from 52s. to 72s. a ton. This assistance was necessary to enable the Australian industry to progress. It was also proposed to vary the bounty on traction engines, in accordance with the amount of Australian or imported material used in their manufacture.

## Random Shots.

It is a lonely furrow that "Marksman" ploughs in his endeavour to find new material to entertain and inform his readers, and, being, like the rest of you, a gregarious soul, any evidence that the furrow is less lonely than he imagined is very welcome. You may therefore imagine his gratification on discovering that he is not the only one who has spent time in the perusal of Lord Aberconway's recent book. . . . No observant reader of this journal, having last week observed "Marksman's" comments on the distinguished peer's conclusions, could have failed to be struck only a few pages later by the quotation of a trenchant sentence from the same source, and illustrating one of the same conclusions. . . .

* * *

The dinner at which the citation in question was made serves to remind us that if conferences and conventions are a joy peculiar to summer and autumn, at least winter can boast the dinner as its own speciality . . . although exactly why one goes to such dinners, and what one asks from them, is not easy to determine. Do we, for instance, ask that speakers should be instructive, or entertaining, or both? No doubt in an ideal world they would invariably be both, but in a world that is, in fact, very far from ideal, all too often, unless they be foundrymen or the guests of foundrymen they are, quite emphatically, neither. * * *

Of course, some people would suggest that we go to a dinner for the sake of meeting people and conversing with them to our mutual benefit; there might even be some who would suggest that we go to a dinner in order to dine . . . it is a complicated problem, and less easy to solve than we are assured by the good folk who compile laborious compendia of after-dinner stories, or advertise their competence to instruct in the art of after-dinner speaking. . . .

* * *

I was interested to note, in view of some recent remarks of mine about the public unwillingness to make use of published figures unless they are nicely selected and dished up for them, that one great ground of objection to the new Insurance Bill has been its incomprehensibility to the average man concerned. It has been suggested that the bill is so bad an example of "legislation by reference" that a consolidating Act is badly needed, in order that the people most intimately concerned should be able readily to ascertain the conditions governing the benefit for which they are eligible.

* * *

But would the average insured person make such use even of a consolidated Act? Would he not rather continue like all the rest of us to amble pleasantly along in the knowledge that there is a law somewhere or other concerning him in this matter of insurance, just as there are laws concerning manslaughter, and motor licences, and being drunk and disorderly? Does any average layman actually trouble himself with the details of the law under which he lives unless or until he is obliged to do so, either because he has contravened it intentionally or unintentionally, or because he wishes to do so?

* * *

It is the same with regulations and by-laws, although an exception might be made for railway by-laws. There are occasions, such as cross-country journeys, when one has reason to be deeply grateful to the authorities for providing us gratuitously with so much entertaining reading matter in waiting rooms and compartments, even though such information was posted for a less diverting purpose.

* * *

Nor does any better success attend the efforts of the extractors—those well-intentioned persons in all walks of life who appear to have a touching belief in the virtue of posting up or framing in conspicuous positions those extracts from relevant laws that they think most desirable of inculcation. What happens is not unlike the effect of the seaside landlady's texts on the mind of the visitor's child: they become, by virtue of mere familiarity, catch-phrases known by heart and devoid of meaning—or else they sink into the background along with the roses and nightingales on the wallpaper.

MARKSMAN.

# Some Further Notes on Oil-Sand and Motor Cylinders.*

By Walter West (Leyland Motors, Limited).

Further to any previous notes that have been written by the author, it might be as well at the outset to state that the results here given represent the beginning of an extensive series of practical experiments to explore the nature and use of all media which might be of service to the foundryman in an oil-sand mixture. There are several factors which qualify a sand mixture for service, and these will vary according to the needs that arise in any given practice. Under certain circumstances it becomes necessary to add proportions of naturally-bonded sand where the work to be carried out is excessively large or the conditions of casting so severe that artificial bonding would be insufficient to hold up against the heat, erosion and pressure of pouring. In these notes, however, *no consideration is given to the use of clay additions* in any form to a mixture of oil sand.

### Rosin as an Agglomerant.

The more important features required of an artificially-bonded mixture can be enumerated as follows: The green bond strength, the strength of the dried core mixture and permanence of the bond. In motor-cylinder work, the greatest difficulty has been to produce a mixture having the requisite strength in the green state to enable cores to stand to some of the complicated and intricate shapes which are becoming much more common with the advanced design of cylinders and their respective head castings. To obtain the maximum of this property, two items are of great importance—first the ingredients composing the mixture, second the mixing treatment to which the mixture is subjected during preparation. In the first instance, previous articles by the author give the main materials which contribute largely in this direction. In addition to these, of late attention has been focused upon the use of rosin as a useful medium for increasing the green bond strength of an oil-core mixture, although this material has been known and used for long years as an addition to naturally-bonded sand-mixtures with satisfactory results. Rosin is obtained from the distillation of oleoresins wherein turpentine spirit is collected and the residue in the vessel when cold sets to the hard substance called rosin. There is a little difference between rosin and some of the resins which exude from trees, but this affects the varnish maker rather than the foundryman owing to its composition and dark colour, which rates the price at a lower figure than the resins.

Rosin is comparatively cheap, and where it is mixed with the right ingredients shows results which are worthy of note. It melts at 120-135 deg. C. and is soluble in most solvents, except water; it can, therefore, be dissolved very conveniently in linseed oil when it is mixed as an ingredient to a sand mixture. Resins and rosins may be used as resinates, *i.e.*, lead, manganese and cobalt being frequently used to accelerate the process of oxidation in varnish making, so that if similar reaction takes place at elevated temperatures it would suggest their usefulness in a core mixture to further expedite the drying process of oil-sand cores where quick process is essential: this point, however, will be the subject of another Paper at a later date.

The very convenience of making additions of rosin dissolved in oil as an ingredient of an oil-sand mixture raised the query whether a greater benefit would be derived by its addition in this form, or as a dry powder. To this end experiments have been conducted to effect some result.

### Test Bars Used.

The commonly used 12-in. × 1-in. × 1-in. core box was chosen in which to make the standard core, and the core so made carefully pushed to the end of a piece of plate glass until the end of the core protruded over to such a length that the weight of the end exceeded the strength of the green sand and broke off. The broken piece was measured and its length stood as a comparative figure to other mixtures.

The mixtures used in the experiments were made in a small experimental "Torrance" mill which has one light muller and plough by which a thorough mixing is obtained. The muller is light in weight and the pressure on the roller can be adjusted at will. To a standard core mixture progressive amounts of rosin were added in two forms:—(a) With rosin dissolved in linseed oil, and (b) with rosin as a dry powder, the following results being obtained:—(1) Effect of (a) rosin dissolved in oil (Table I) and (2) effect of (b) rosin powdered in the dry (Table II), upon the green-bond strength.

TABLE I.—"a" *Series of Experiments.*

| Percentage of rosin. | Green-bond strength. Per cent. | | |
|---|---|---|---|
| 0.15 | 1.10 | 1.10 | 1.15 |
| 0.3 | 1.10 | 1.15 | 1.10 |
| 0.45 | 1.10 | 1.15 | 1.10 |
| 0.60 | 1.10 | 1.15 | 1.10 |
| 0.75 | 1.10 | 1.15 | 1.10 |
| 0.90 | 1.25 | 1.25 | 1.25 |
| 1.05 | 1.25 | 1.30 | 1.25 |
| 1.20 | 1.25 | 1.30 | 1.25 |
| 1.35 | 1.30 | 1.30 | 1.30 |
| 1.50 | 1.35 | 1.40 | 1.40 |

TABLE II.—"b" *Series of Experiments.*

| Percentage of rosin. | Green-bond strength. Per cent. | | |
|---|---|---|---|
| 0.15 | 1.0 | 1.0 | 1.1 |
| 0.3 | 1.0 | 1.0 | 0.95 |
| 0.45 | 1.0 | 1.0 | 1.0 |
| 0.60 | 1.0 | 1.0 | 1.05 |
| 0.75 | 1.10 | 1.10 | 1.0 |
| 0.90 | 1.20 | 1.25 | 1.25 |
| 1.05 | 1.20 | 1.30 | 1.20 |
| 1.20 | 1.40 | 1.40 | 1.50 |
| 1.35 | 1.60 | 1.60 | 1.65 |
| 1.50 | 1.60 | 1.65 | 1.70 |

A graphical representation (Fig. 1) of these results shows a distinct lag at the beginning of each series where the green-bond strengths of the mixture differ but little; when the additions, however, reach 0.90 per cent. in both cases there is a marked increase in the strength which rises more rapidly as the higher percentage additions are made in the dry state. This may possibly be due to the influence of the bulk of dry powdered rosin exerting a frictional resistance between the sand grains, in which case it might be reasonable to expect that the addition of any dry impalpable powder not injurious to the final quality of the core might produce a corresponding increase in the green-bond strength of the mixture. In any case, it would be difficult to find a substance more suitable than powdered rosin for this end, having such a blend of properties, so convenient for the production of the ideal type of hard smooth faced core with the necessary permeability. To obtain evidence that dry powder rosin when mixed with oil in a sand mixture exerted a physical effect over and above that obtained when using it dissolved in oil, many experiments have been carried out, two only of which will be sufficient to illustrate the point.

Taking the same progressive amounts of dry powdered rosin in each case—two quantities of oil additions are shown in proportion to the quantity of sand, no other additions being made. The mixtures were made in an experimental "Torrance" mixer for exactly the same period of time for each.

When the proportion of oil to rosin or sand is the smaller as in the first series, the green bond strength of the mixture rises corresponding to the addition of powdered rosin, as shown by the full line curve in the graph, Fig. 2. the sand darkens in colour and towards the maximum percentage addition shown, the mixture sticks very badly to the core box, making it very difficult to produce a good draw. It was particularly noticeable, also, that the hardness of the dried core increased as the increase of the rosin additions which would indicate a very useful property of this substance, when hardness and strength in the dried condition is required of a sand core.

In the second series where the proportion of oil to rosin or sand is much greater, the results obtained show a very much quicker and greater rise in the green bond strength of the mixture as the rosin additions increase until a maximum is reached at 1.6 per cent. when the strength somewhat decreases. Up to this maximum the sand mixture was good to work and left the core box in the usual way without sticking, but above this percentage, the mixture became sticky and eventually unworkable.

TABLE III.—*Rosin added dry* (1½ *lbs. sand to* 5 *c.c. oil*).

| Per cent. rosin addition. | | Green-bond strength. Per cent. |
|---|---|---|
| To oil. | To sand. | |
| | 0 | 0.75 |
| 22.5053 | 0.15 | 0.80 |
| 45.0106 | 0.30 | 0.85 |
| 67.5159 | 0.45 | 0.90 |
| 90.0212 | 0.60 | 0.95 |
| 112.5265 | 0.75 | 1.00 |
| 135.0318 | 0.90 | 1.15 |
| 157.5371 | 1.05 | 1.15 |
| 180.0424 | 1.20 | 1.25 |
| 202.5477 | 1.35 | 1.25 |
| 225.0530 | 1.50 | 1.35 |
| 247.5583 | 1.65 | 1.30 |
| 270.0636 | 1.80 | 1.40 |
| 292.5689 | 1.95 | 1.45 |
| 315.0742 | 2.10 | 1.40 |
| 337.5795 | 2.25 | 1.55 |
| 360.0848 | 2.40 | 1.50 |
| 382.5901 | 2.55 | 1.55 |
| 405.0954 | 2.70 | 1.55 |
| 427.6007 | 2.85 | 1.60 |
| 450.106 | 3.00 | 1.70 |

TABLE IV.—*Rosin added dry* (1½ *lbs. sand to* 17.75 *c.c. oil*).

| Per cent. rosin addition. | | Green-bond strength. Per cent. |
|---|---|---|
| To oil. | To sand. | |
| | 0 | 0.85 |
| 0.605 | 0.15 | 1.05 |
| 1.211 | 0.30 | 1.10 |
| 1.817 | 0.45 | 1.20 |
| 2.423 | 0.60 | 1.35 |
| 3.029 | 0.75 | 1.40 |
| 3.635 | 0.90 | 1.30 |
| 4.240 | 1.05 | 1.35 |
| 4.846 | 1.20 | 1.50 |
| 5.452 | 1.35 | 1.55 |
| 6.058 | 1.50 | *1.60* |
| 6.663 | 1.65 | *1.60* |
| 7.269 | 1.80 | 1.45 |
| 7.875 | 1.95 | 1.45 |
| 8.4814 | 2.10 | 1.50 |
| 9.089 | 2.25 | 1.40 |
| 9.692 | 2.40 | 1.40 |
| 10.298 | 2.55 | 1.50 |
| 10.904 | 2.70 | 1.45 |
| 11.510 | 2.85 | 1.55 |
| 12.116 | 3.00 | 1.55 |

### The Effect of Mixing and Milling Upon the Grain Size of a Sand Mixture.

The general trend of foundry thought is to conclude that oil-sand mixtures are best produced in some type of mixer which will not break the grains of the sand, and hence there is offered on the market the various types of paddle mixer or some design very similar in principle. It is, however, a conclusion which has been generally accepted rather from the makers of the machinery than a result of experimental work. Foundrymen for many decades have been aware that the application of work in the manner of treading with the feet causes a sand mixture to be considerably tougher to the feel and better to mould into shape than when mixed with the shovel only. The explanation is, that the work of treading causes a more intimate and evenly distributed contact between the grains of sand and the clay bond. In a similar way, the delicacy and

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* Paper read before the Newcastle Branch of the Institute of British Foundrymen, Mr. Victor Stobie, presiding.

frailty of the shapes required in the majority of cores for motor cylinders call for the highest degree of strength from the sand mixtures, and it is found in the preparation of oil-sand mixtures that the application of work in the form of a moving weight upon the sand produces a greater strength in the mixture. The diagram below shows the difference effected by three different types of sand mixers using three standard sand mixtures.

*Series* 1 (Fig. 3) illustrates the degrees of green grains for the bonding material to cover, which would be reinforced in the interstices by the finer grained sand.

In all the series it will be noticed how the strength of the sand is increased in proportion to the work applied during mixing.

The point now arises, to what extent is damage done to the grains of the sand when subjected to the weight of the heavy rollers. By taking Series 3, where the coarse-grained sand was used, a much better opportunity will be afforded of measuring more accurately than in the case of the other mixtures. To this end samples of the sand mixture after each treatment were taken and ignited thoroughly to burn off the volatile bonding material, after which 100 grammes of the ignited sand were put through a set of standard sieves, and the amount of sand retained on each size of sieve weighed and expressed as percentages. The graphs shown in Fig. 4 express the results. It

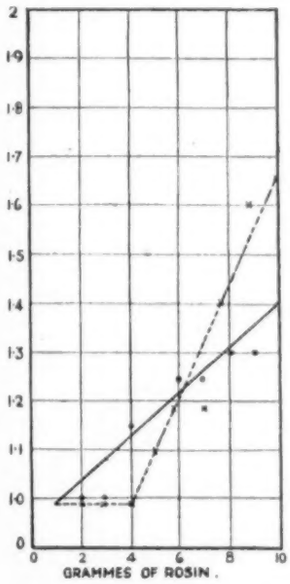



Fig. 1.—Curves showing Difference in Green Bond between Sand with Rosin Additions Dissolved in Oil (full line) and Sand with Powdered Rosin Addition (dotted line).

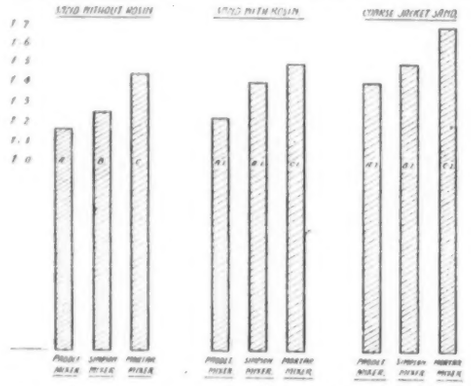


Fig. 3.—Green Bond Strength of Oil Sand Mixtures.

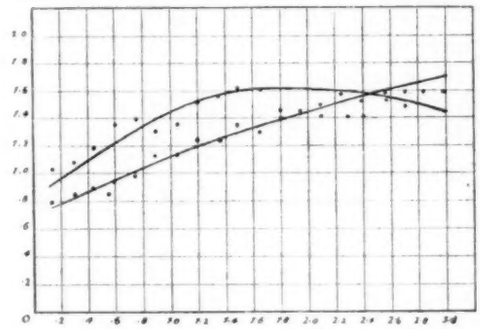
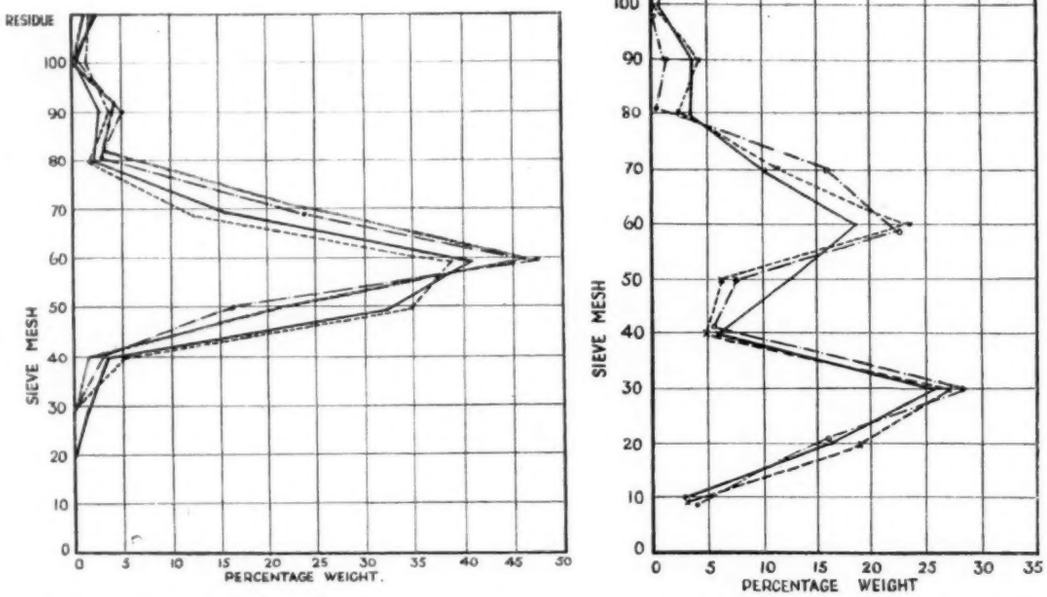


Fig. 2.—Effect of Rosin Additions to Oil and Sand in Relation to Green Bond Strength.




Figs. 4 and 5.—Effect of Milling upon the Grain Size of Oil Sand Mixtures, Coarse Jacket Sand made from Equal Parts of No. 6 Leighton Buzzard and Shore Sand. Paddle Mixer indicated by full line; Simpson by dotted line; Mortar Mill by dot and dash line, and Shore Sand by Hatched line.

bond strength obtained from the same mixture but mixed (1) an old type of Fordath paddle mixer; (2) the latest type of double Simpson muller mixer; and (3) an ordinary type of mortar mill with two plain mullers.

*Series* 2 (Fig. 3) shows the results obtained from similar experiments as Series 1, but with the addition of 0.50 per cent. rosin, which explains the total increase in strength of the mixture.

*Series* 3 is of a very interesting nature on account of the general idea that a coarse grain sand is necessarily weaker than one of fine grain—this is not so, for in these experiments a very coarse Leighton Buzzard sand was mixed with equal quantity of shore sand, and although the quantities of the artificial bond added were slightly different from the previous mixture, yet this was not enough to account for the very marked increase in green bond strength obtained. The explanation is no doubt to be found in the larger surface area which is exposed around the larger

Table V.—*Sieving Tests on Various Sands.*

| Shore sand mixture. | Size of Sieve (meshes to sq. ins.). | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mixture from | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | Rem. |
| | % | % | % | % | % | % | % | % | % | % | % |
| Paddle mixer .. .. .. | — | 0.30 | 1.5 | 3.8 | 32.5 | 41.0 | 15.5 | 1.70 | 2.7 | 0.20 | 0.70 |
| Simpson mixer .. .. .. | — | — | 0.2 | 5.2 | 34.7 | 39.5 | 12.9 | 1.40 | 4.2 | 0.10 | 1.30 |
| Mortar mill .. .. .. | — | — | 0.5 | 3.3 | 16.5 | 47.5 | 23.5 | 1.70 | 5.2 | 0.20 | 1.50 |
| Shore sand before use.. .. | — | — | 0.32 | 1.59 | 21.4 | 46.3 | 23.3 | 1.52 | 4.31 | 0.39 | 1.42 |

Table VI.—*Sieving Tests on Coarse Sands.*

| Coarse sand mixture. | Size of sieve (meshes to sq. ins.). | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mixture from | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | Residue. |
| | % | % | % | % | % | % | % | % | % | % | % |
| Paddle mixer .. .. | 2.8 | 16.75 | 25.95 | 6.3 | 12.16 | 19.0 | 10.85 | 1.97 | 2.65 | 0.27 | 0.93 |
| Simpson mixer .. .. | 3.37 | 19.0 | 27.0 | 4.7 | 6.7 | 23.0 | 11.4 | 1.20 | 2.75 | 0.17 | 0.65 |
| Mortar mill .. .. | 3.80 | 16.5 | 28.0 | 5.0 | 7.5 | 22.6 | 15.7 | 0.05 | 0.10 | 0.07 | 0.78 |

will be seen that there is very little difference in the grain size of the three mixtures, the greatest degree of difference occurs between the sieves 60 and 80, but is not disturbing.

The lower grain sizes are of an equal regularity which is a definite proof that grinding of the sand grains does not take place, where the dry sand is allowed to be milled for any length of time without the additions of oil, etc., necessary for the mixture, it is to be expected that a breaking-up of the grains will occur. It is the author's opinion that the additions of oil, molasses, etc., act as a lubricant and a preventative against the trouble generally anticipated.

In Tables V and VI are the figures of two experiments, using, in the first place, shore sand only in the mixture, and in the second a mixture of equal quantities of coarse Leighton Buzzard and shore sand.

These results, stated graphically in Figs. 4 and 5, are very interesting, and illustrate the point claimed with greater distinction than the tables of figures. Particular note should be made of the results obtained from the shore sand mixture—comparing the trend of the curves from each type of mixture with that of the unmilled shore sand. The results here given are entirely reliable, representing a mean of many trials, at the same time being actual results obtained.

## Treatise on Foundry Practice.

In 1923 we published the following list of books dealing with foundry practice, and as we are constantly being requested for this information, we are reprinting it, with but one addition, and ask readers, technical societies and publishers to draw our attention to any that are missing.

METALLURGY OF CAST IRON. By J. E. Hurst. Sir Isaac Pitman & Sons, Parker Street, Kingsway. 15s.

THE PRINCIPLE OF IRON FOUNDING. By Sexton & Primrose. The Technical Publishing Company, Limited, 55-56, Chancery Lane, W.C.

IRON FOUNDING. By B. Whitley. Sir Isaac Pitman & Sons, Parker Street, Kingsway, London, W.C.2. 3s.

AMERICAN FOUNDRY PRACTICE. By T. D. West. Chapman & Hall, Limited, 11, Henrietta Street, London, W.C.2. $2.50.

GENERAL FOUNDRY PRACTICE. By W. Roxburgh. Constable & Company, 10, Orange Street, Leicester Square, London, W.C. 10s. 6d.

NOTES ON FOUNDRY PRACTICE. By J. J. Morgan. Chas. Griffiin & Company, Limited, Exeter Street, Strand, London, W.C.2.

IRON FOUNDRY PRACTICE. By G. J. Pitt. Cassell & Company, Limited, La Belle Sauvage, E.C.4. 6s.

FOUNDRY PRACTICE. By R. H. Palmer. Chapman & Hall, Limited. 15s. 6d.

FOUNDRY (IRON, STEEL AND BRASS). By F. Foster. Iliffe & Sons, Limited, 20, Tudor Street, London, E.C.4. 2s.

BRITISH RESOURCES OF REFRACTORY SANDS. By P. Boswell. Taylor & Francis, Red Lion Court, Fleet Street, E.C.4. 8s. 6d.

CAST IRON IN THE LIGHT OF RECENT RESEARCH. By Dr. W. E. Hatfield. Chas. Griffin & Company, Limited. 12s. 6d.

GENERAL FOUNDRY PRACTICE. By A. McWilliam and P. Longmuir. Chas. Griffin & Company, Limited. 15s.

PRACTICAL IRON FOUNDING. By J. G. Horner. Whittaker & Company, 2, White Hart Street, Paternoster Square, London, E.C.

THE ART OF PATTERN-MAKING. By J. Chase. Chapman & Hall, Limited.

FOUNDRY MACHINERY. By E. Treiber. Scott, Greenwood & Son, 8, Broadway, Ludgate Hill, E.C. 3s. 6d.

MOULDERS' TEXT-BOOK. By T. D. West. Chapman & Hall, Limited. $2.50.

PATTERN-MAKING. By J. Kelly. The Machinery Publishing Company, Limited, 51, Chancery Lane, W.C.2.

FOUNDRY MOULDING MACHINES AND PATTERN EQUIPMENT. By E. S. Carmen. Penton Publishing Company, Limited, Caxton House, S.W.1.

PRODUCTION OF MALLEABLE CASTINGS. By R. Moldenke. The Penton Publishing Company, Limited, 2, Caxton House, Westminster, S.W.1.

BRASSFOUNDING. By J. Horner. Emmott & Company, 65, King Street, Manchester.

MODERN IRON-FOUNDRY PRACTICE. By G. R. Bale. The Technical Publishing Company, Limited, 287, Deansgate, Manchester. 3s. 6d.

FOUNDRYMAN'S HANDBOOK. Penton Publishing Company, Limited.

CAST IRON. By W. J. Keep. Chapman & Hall.

A COMPARISON BETWEEN BRITISH AND AMERICAN FOUNDRY PRACTICE, WITH SPECIAL REFERENCE TO THE USE OF REFRACTORY SANDS. By P. G. H. Boswell. Hodder & Stoughton, Limited, Warwick Square. 4s. 6d.

AMERICAN MALLEABLE CAST IRON. By H. A. Schwartz. The Penton Publishing Company, Limited. 35s.

PRACTICAL PATTERN-MAKING AND MOULDING. By W. H. Wilson. John Heywood, 2, Amen Corner, London, E.C.

GUN-METAL AND BRASS FOUNDING. By H. S. and J. S. G. Primrose. Louis Cassier & Company, Bedford Street, London. 10s.

FOUNDRY WORK. By B. Shaw and J. Edgar. Sir Isaac Pitman & Sons, Limited. 2s. 6d.

THE PRINCIPLES OF IRON FOUNDING. By R. Moldenke. McGraw Hill Company. 30s.

MALLEABLE CAST IRON. By S. Jones Parsons. Constable & Company. 8s.

MODERN FOUNDRY PRACTICE. By John Sharp. E. & F. Spon, 57, Haymarket, S.W.1. 21s.

OPEN-HEARTH STEEL CASTINGS. By W. M. Carr. Penton Publishing Company. 7s. 6d.

FOUNDRY COST ACCOUNTING. By R. E. Beet. Penton Publishing Company. 85.

FOUNDRY PRACTICE. By Tate and Stone. John Wiley & Sons. 8s. 6d.

PRACTICAL PATTERN MAKING. By F. W. Barrows. The Norman W. Henley Publishing Company, New York. 6s.

PRINCIPLES AND PRACTICE OF IRONFOUNDING. By E. L. Rhead. Scientific Publishing Company, Manchester. 7s. 6d.

PRACTICAL ALLOYING. By J. F. Buchanan. Penton Publishing Company. $5.

THE CUPOLA FURNACE. By Edward Kirk. E. & F. Spon. 15s.

FOUNDRY IRONS. By Kirk. Baird.

THE STEEL FOUNDRY. By Hall. McGraw Hill Company, 6, Bouverie Street, E.C.4.

LECTURES ON IRON FOUNDING. By Thos. Turner. Chas. Griffin & Company.

## Oxygen in Iron and Steel.*

BY P. OBERHOFFER, H. J. SCHIFFLER AND W. HESSENBRUCH.

The authors, in the Summary to their Report of the Committee for Working Materials of the Association of German Ironmasters, make the following statements:—

As regards the influence of oxygen on the primary and secondary structure of iron and steel, they remark that in numerous vacuum meltings, consisting of electrolytic iron and ferrous oxide, a distinct segregation of crystals was observable after the first etching. As the amounts of phosphorus and carbon present were too slight to account for this segregation, it had to be attributed to the oxygen present in solid solution.

It was possible to determine a maximum value for the distinctness of the primary structure, which value apparently coincided with the upper limit of solubility of the oxygen in the iron at room temperature. With higher oxygen contents the primary etching became less distinct. By means of deoxidising agents the maximum value of the distinctness was apparently altered in accordance with lower oxygen contents.

The same phenomena in regard to the primary etching were proved to occur in a series of alloy steels, which were prepared in pairs. Of these, one of each pair was melted in the ordinary way in an oil furnace, while its fellow was enriched with oxygen by blowing in air before admixing the alloying metal. Steels rich in oxygen generally showed a primary structure, while this was absent in the steel low in oxygen with which it was compared. The greatest clearness in the primary etching was, moreover, found in these steels also with medium oxygen content.

In overblown steels the secondary etching showed a rather coarse grain, an inner-crystalline structure of the ferrite and a great fluctuation in the number of inclusions from grain to grain. Speaking quite generally, it may be said that steel with a high oxygen content showed an irregular and indistinct secondary structure.

As regards the influence of oxygen on certain properties of alloy steels, the authors state that a series of samples of steel were melted in pairs, the two samples of each pair having the same composition with the exception that one sample of each pair was enriched with oxygen by blowing in air previous to casting. These samples were tested in various respects in their cast and wrought state. In addition the oxygen was determined by the hot-extraction process.

The influence of the different alloying metals on the malleability and red-shortness, was examined. It was shown that red-shortness did not depend on the oxygen content alone, but this question could not be definitely settled on the basis of the tests already carried out.

In the case of very poor steels with high oxygen contents good malleability could only be obtained when they contained more than 0.5 per cent. of aluminium. The bottom of the ingot showed a somewhat higher oxide content (inclusions) than the middle and the top, and behaved generally much less satisfactorily in forging.

Without exception the cementation tests with steels high in oxygen produced (irrespective of their composition) a rather fine grain, a fine roundish cementite network, and a cementation zone of slight depth. In the case of steels having an aluminium content of about 1 per cent. a very weak hyper-eutectoid zone was only obtained.

In the hardness tests the steels with a high oxygen content showed a liability to overheating, and therefore possessing a small hardness range with rather coarse martensite or troostite. In the case of steels high in oxygen the overheating tests produced a rather coarse grain, needle ferrite and general irregularity of structure. In these steels, in contrast with those with low oxygen content, nitrogen needles could be observed after annealing. The regeneration tests showed no particular differences between steels high and low in oxygen.

In the decarbonisation tests the steels containing oxygen generally showed a thicker coating of scale and decarbonised zone. The forging tests for the purpose of producing a slaty fracture, showed, in the case of steels with high oxygen contents throughout, a characteristic slaty and wood-fibre fracture, which was attributable to a primary segregation due to the presence of oxygen.

* Archiv für das Eisenhüttenwesen.

## The Continental Steel Trust.

Representatives of the groups forming the Continental Steel Trust assembled in Brussels on December 8 and 9 as arranged. After a discussion of the situation on the market, it was decided to maintain the rate of production during the ensuing quarter at the same figures as in the current quarter. On behalf of the Central European countries who are members of the Trust, an application was made to increase their quota and at the same time to reduce the penalty for exceeding the allotted output. These questions, however, were deferred for consideration at the next meeting of the Trust to be held in Paris on March 9, 1928.

The question of the proposed selling organisations for semi-finished material and shapes again came forward for discussion at the Brussels conference, but apparently no progress was made. The Belgian group is said to have put forward a new demand in the form that the French and Germans should abstain from disposing of semi-finished material and shapes in the Belgian market, but this proved to be unacceptable to the two groups concerned.

Taking advantage of the presence of the steel makers in Brussels, a meeting took place of the members of the Erma (European Rail Makers' Association), under the presidency of M. Greiner, of the Cockerill Works. Current business was discussed and the orders received were divided among the different groups. No change was made in the sale price. Sale conditions continue to be satisfactory.

# Electric Power in the Foundry—IV.

By "Kilowatt."

### An Up-to-Date Foundry.

Before proceeding to deal with what might be termed the miscellaneous application of electric power in the foundry, *i.e.*, driving of compressors, moulding machines, fans, sand mills, hammers and so on, the following details of a new all-electric charging equipment in an American foundry may be of interest to the foundry industry of this country, as it offers a good example, electrically and mechanically, of modern practice in the application of electricity in the handling of material in the foundry. All the furnaces, which by the way are of the electric arc type, are served by a new type of charger, which is one of the features of the installation. This machine, which is a low, floor-type unit of 5-ton capacity, is not only believed to be the first of its kind to be equipped with worm gear drive but the first to be supplied throughout with standard tapered roller bearings. The construction and operation of the machine are, briefly, as follows:—The trolley frame and end castings are both solid one-piece castings, a construction that eliminates the necessity for mounting the driving motors and shafts on separate supports bolted to the frame. The charging ram which is of forged steel, is raised and lowered by means of two crank-shafts, which are driven by a 40-h.p. motor through a worm gear having a speed reduction ratio of 20 to 1. The shafts of both the worm and wheel respectively of the gear are equipped with three sets of tapered roller bearings, the two inboard bearings being of the single and the outboard, or pinion, bearing being of the double type. The ram is rotated by a 5-h.p. motor, which drives it through a set of spur gears.

Cross-travel mechanism is driven through a worm gear by a 30-h.p. motor located at right angles to the direction of travel. In this case, also, both the worm and wheel shafts of the train run on tapered roller bearings, the arrangement for both being the same as that for the hoist gear. Bridge travel is obtained by two 40 h.p. motors, one on each side of the bridge, each of which drives its own set of track wheels through a geared line shaft. The shaft and all the wheels are completely equipped with tapered roller bearings. The entire control is of the magnetic time-limit variety.

Among the outstanding advantages claimed for this machine are, the substitution of worm for spur gears rendering the machine simpler, and therefore easier to operate and maintain. The number of moving parts and the friction load imposed by those actually incorporated in the machine are greatly reduced, thus making it possible to use motors of a lower horse-power, with a consequent saving in power consumption. The combination of worm drive and the liberal use of roller bearings have minimised the lubrication expense, besides making the machine much easier running and thereby lengthening its useful life. Last, but not least, a construction has been permitted that gives the operator an unobstructed view of the end of the ram, the charge, the floor, and the interior of the furnace.

### The Ladle Crane.

On the pouring side of the building is a 165-ton ladle crane, also equipped with worm-gear drive and roller bearings throughout. The crane is of the four-girder type, and in addition to the 165-ton main hoist is equipped with a 50-ton auxiliary trolley and a 15-ton auxiliary hoist. A novel arrangement has been developed for the drive of the main hoist, which, in addition to simplifying its operation and construction, adds considerably to its safety features. The main hoist drive shaft consists of two sections of equal length butted together and connected by a flexible coupling. Each section has a 110-h.p. driving motor at the far end, which is connected through a flexible coupling to a worm gear, which drives one of the hoisting drums through a pinion mounted on the shaft of the worm wheel. A solenoid brake is mounted on each section between the worm gear and the main coupling in the centre. The effect, therefore, is that of a continuous shaft with a driving motor, gears and brakes at each end. The two hoisting drums are so located that their driving gears are parallel, and while under normal conditions they do not make contact, in case of failure of a drum pinion, shaft or worm gear on either end of the main shaft they will make contact, so that the solenoid brake on the section of the shaft that is still operative can hold both drums stationary and prevent the load from dropping.

The control for the main hoist drive also has some interesting features. It is of the magnetic time-delay type, and consists essentially of two complete control systems, one for each motor, which are operated by a common master switch. The two are connected through the master switch so that their sequences in hoisting and lowering operate simultaneously and the motors are brought up to speed in perfect synchronism. Therefore there is no possibility of a twisting strain being applied to the main shaft owing to one motor exerting a different degree of torque or running at a different speed from the other. In case power on one motor fails for any reason, both are disconnected and the two solenoid brakes set, so that there is no tendency for one motor to try to drive the shaft against the brake of the motor that is out of commission. The control provides dynamic braking on both motors on both hoisting and lowering motions, which, in the case of the latter, is applied to reduce the motor speed before solenoid brakes are set.

The rest of the control, that for the bridge, trolley and auxiliary hoist motions, is of the standard magnetic time limit variety. In this case, as in that of the charger, the two elements of the worm gears are mounted on roller bearings, the arrangement being the same as that described on the charger. The rest of the drives on the crane are of the spur gear variety, the trolley being driven by a 40-h.p. motor through two sets of gears, and the bridge travel mechanism by two 90-h.p. motors.

### Electric Tools in the Foundry.

The use of portable electric tools such as drills, grinders and hammers, etc., in the foundry is rapidly on the increase. The advantage claimed by this method is the reduction of heavy initial expenditure on compressor plants, pipe systems and their installation and lower running costs.

Originally all electric tool motors were totally enclosed, and this was considered the best practice until forced ventilation was introduced, and it was then found to be so great an improvement that the totally enclosed motors were discontinued. Under the heading of portable electric tools the electric drill comes first in popularity. Then there are portable electric grinders for use in foundries, machine shops and general engineering processes, with hand or tool-part attachments, and miscellaneous tools, such as hammer drills, blowers, etc.

### Three-Phase High Frequency Portable Electric Tools.

This equipment is intended to meet the demand for portable electric tools for production work, where it is necessary to run them for long periods at a time and where they are likely to be subjected to very severe usage.

The advantages claimed for the high-frequency system is reduced weight, power increased and maintenance reduced, and represents altogether the greatest step forward in portable tool design since the introduction of the electric drill.

The underlying idea is as follows:—The induction motor which operates on single, two or three-phase electric supply, as is well known, requires less attention than an equivalent d.c. motor, chiefly on account of the absence of commutator and brushes, as well as the more constant speed. The rotor in the induction motor, moreover, is practically immune from burning out, while a very heavy load would be carried before the stator windings would be subject to this trouble, whereas in the case of the direct-current motor, both the armature and field coils are liable to burning out.

It will, therefore, be clear that the squirrel-cage induction motor is capable of withstanding much heavier overloads than direct-current motors of corresponding size. The advantages of the induction motor apply equally to the smaller motors of this type in portable electric tools. Their chief disadvantage has been that the periodicity limits the speed, and consequently the power, which can be generated in a particular size machine.

With any portable electric tool, the power developed under load with a given size of armature, assuming that the best design of winding has been used, depends upon the speed under load and is almost in direct proportion to that speed. Taking, for instance, the size of machine which has been developed in the high-frequency type for drilling and reaming up to 1 $\frac{5}{8}$ in., this drill, as a portable drill of the usual type, has an armature speed of 11,000 r.p.m. light load, and a load speed of 4,800 r.p.m. If by some means the load speed can be increased to 9,600 r.p.m., the power of the tool will be practically doubled. The limiting speed in a series-wound d.c. motor is, of course, the free speed, and could not be increased with any degree of safety to the extent required to give a load speed of 9,600 r.p.m.

In the a.c. induction-type tool, with all its inherent advantages, at 50 cycles the maximum speed is 3,000 r.p.m. (with a two-pole motor). With the high-frequency type, at 200 cycles, the speed of the two-pole motor will be 12,000 r.p.m., and at full load the drop in speed will be approximately 8 per cent., giving a speed of 11,040 r.p.m. It is obvious, therefore, that while the free speed of the 200-cycle tool is no higher than the drill referred to, the load speed is more than double, so that more than twice the power will be developed with the same size of motor or armature. As compared with the ordinary 50-cycle induction motor, practically three times the power will be developed.

For the high-frequency machines developed on these principles it is claimed:—

(1) That increased power is available on account of the constant high speed under load in comparison with d.c. or 50 cycles a.c. tools.

(2) Because of this increased power, the weight is approximately two-thirds that of the d.c. drills of the same capacity and half the weight of the d.c. grinders of equal capacity.

(3) On all loads constant speed is maintained. A direct-current motor, series wound, such as is generally used on small tools, slows down as much as 51 or 60 per cent., although fairly constant speed can be attained with shunt or compound windings. The sustained speed of the high-frequency machine enable the accomplishment of more work.

(4) That important factor, *maintenance cost*, is reduced by a third that of the direct-current machine through:—(*a*) Absence of commutator and brushes; (*b*) squirrel cage rotor wound with bare copper, which is practically impossible to burn out; and (*c*) the tool is mechanically stronger than any d.c. machine on the market, a feature rendered possible by the lesser weight, due to high-sustained speed, so that even with mechanical parts strengthened the weight is still two-thirds that of the d.c. machine.

The full load of a machine of this description is 4.00 k.v.a., or 3.5 k.w., taking the power factor into consideration. The chief point emphasised for the type of equipment under review is saving in maintenance cost.

These high-cycle machines cannot, of course, run on circuits or ordinary periodicity. The tendency for a long time has been to lower the periodicity of the supply, and to-day 50 cycles, or in some cases 40, is about the normal. It is necessary, therefore, to supply these high-cycle machines from special generators giving a periodicity of about 200 cycles per second. The size of this generator would depend on the number of machines it is desired to use. As some guide, however, one machine of the type under discussion requires 4.5 k.v.a.

# The Production of Diesel Engine Castings in Pearlitic Cast Iron.

At a meeting of the Sheffield Branch of the Institute of British Foundrymen, held at the Albany Hotel, Mr. A. J. Richman, of Ipswich, gave an interesting lecture on "The Production of Diesel Engine Castings in Pearlitic Cast Iron."

Mr. Richman's Paper was illustrated with lantern slides of moulding machines, moulds, methods of moulding, special runners, and finished castings. He explained a hardness theory as it affected the wearing qualities of cast iron. Regarding the resistance to wear of pearlitic cast iron in relation to the Brinell hardness, the lecturer said the Brinell hardness was only a comparative test of its resistance to abrasion. It was not the iron that gave the highest hardness figure that resisted wear the best when the wear of engine liner was considered.

To make a similar comparison they could take a babbit metal (antimony: tin: copper). Although this metal gave exceptional resistance to wear the Brinell hardness was very low. The reason for this was that the alloy in its constitution had two hard constituents, the antimony tin cubes and the antimony-tin-copper stars. These took care of the wear, whilst the soft tin-rich base constituent acted as channels for the lubricant.

Another well-known metal to resist wear was gunmetal (copper: tin: zinc). In this case the hard Delta (tin-rich) constituent takes the wear, whilst the Alpha (soft) copper-rich base constituent acted as channels for the lubricant. When this was compared with cast iron they found that the hard constituents which take the wear were the phosphide meshwork and the cementite constituent of the pearlite. The ferrite constituent of the pearlite was the soft base metal, and this acted as channels for the lubricant. The best structure was one which was all pearlite, with small uniformly distributed curly graphite structure through it, and having a Brinell value of about 190.

### Wear and Brinell Hardness.

The President (Mr. A. Firth) said they would all join with him in expressing appreciation of Mr. Richman's most interesting and instructive lecture. The President added that Mr. J. S. Glen Primrose, President of the Lancashire Branch of the Institute, had written to express his regret that pressure of business had prevented him attending Mr. Richman's Paper that night, so that he might join with others in expressing his appreciation of the valuable work recorded in the Paper, showing the value of metallurgical control in the production of high duty cast iron, possessing regular physical properties as well as fairly definite chemical composition.

It was very clearly demonstrated by the author of the Paper that great importance attached to two things in getting the best heat-and-growth resisting iron for liners and cylinder heads as well as pistons, namely (1) the production of suitable cooling rates of the smallest possible graphite particles, preferably of the well-known curly formation, and (2) the matrix of maximum pearlite constitution, cut up by as small a proportion as convenient of the separated phosphide patches. A recent determination had shown that this maximum pearlite composition could be attained without having as much as the usual 0.9 per cent. combined carbon expected from the constitutional diagram, and the new value for an iron with 1.0 per cent. silicon had been placed as low as 0.69 per cent. combined carbon.

The question of resistance to wear had recently been investigated, and it was clearly evident from the results over a wide range of irons from low carbon, low silicon to high carbon, high silicon, that there was a close relationship between the resistance to wear and the Brinell hardness number. Ferritic irons wear down very rapidly, giving under the standard conditions a loss of 95 grammes per hour under a running load of only 50 lbs. distributed over a contact area of 9 sq. ins., this corresponded with a Brinell value of 130 only. But with the pearlite matrix in the iron the Brinell values ranged from 180 to 210, and the wear figure dropped to just under one gramme per hour, which was the maximum resistance to wear experienced. With irons containing more than the eutectoid proportion of combined carbon, the wear was somewhat faster, due no doubt to some particles of the iron carbide breaking out and acting as a sharp abrasive.

Another item considerably increasing the wear resistance was the use of nickel, and some recently published figures indicated that 3 per cent. of this added element had reduced the wear of a grey iron, as found in the Amsler abrasion testing machine, to one-fortieth that of the same composition of iron without the added nickel. He would ask the author to state if he had found the effect of small quantities of nickel or chromium to assist in retaining the matrix of grey iron, from low silicon metal, in the pearlitic, or more desirably the sorbitic condition.

In a recent Paper published in "The Transactions of the American Society for Steel Treating," Mr. Coyle had described some of his experiments on "The Heat Treatment of Cast Iron for Diesel Engines," in which he claimed that both ordinary and high-test cast iron was very materially improved by a double heat treatment, consisting of quenching in oil from 800 deg. C. He would like to ask Mr. Richman if he had been able to effect any such improvement in his high test irons, either experimentally or in full scale castings, which would naturally have to be of simple design to withstand any heat treatment without distortion or possible rupture.

MR. RICHMAN said that Mr. Primrose's contribution to the discussion confirmed somewhat the results obtained for the Brinell relation to wear. As regards the nickel addition to cast iron he had not experimented with it up to now. He had read with interest the Paper by Mr. Coyle, and it would form the basis of a very interesting experiment for the future. The Diesel engine is only in its infancy, and as time went on and the demand of the engine designers became more stringent, foundrymen will have to progress as regards producing castings to withstand the ever increasing strain and wear demanded by the designer.

### Payment for Improved Castings.

MR. J. T. GOODWIN (President of the Institute) said the Paper they had heard was one of the best they had listened to for a long time. Mr. Richman had dealt with his subject in a way that touched the foundation of the foundry business. They had the metallurgical side based on a practical demonstration. They could see from the descriptions of the mouldings that they were up against many problems, but they had overcome them, and from what Mr. Richman had shown them they had made a huge success of it. As a supplier of castings he found the greatest difficulty in obtaining a little money per ton for castings of the type Mr. Richman had shown to compensate them for the extra care and specialised metallurgical control required to produce them. He hoped the time would come when the increased cost to produce special castings would be appreciated and paid for. He would like to ask Mr. Richman to be good enough to repeat the charges that were put into the cupolas and the different analyses obtained. The charging of the cupolas was of vital importance, and he asked him to give them the method of charging. With regard to the Brinell hardness test, they had a greater relationship between the hardness and phosphorus than was appreciated. This experience was quite definite. Had Mr. Richman data showing the effect of the reduction of phosphorus.

MR. RICHMAN, in reply, said that the irons used were ordinary irons (not cold blast or special irons) and the scrap was domestic cylinder headers, etc., the analysis of which was known. It was desirable to know the composition of all the irons used in the charge, as with the silicon under 1.0 per cent., and a fairly low total-carbon the ultimate iron in the castings was what was termed a border line iron, where a slight lowering of either of these constituents resulted in a mottled iron. The cupola was charged in the usual way, the steel being charged on the top of the coke charge before the pig-iron and scrap. He blew at 8 oz. pressure with a tuyere of $\frac{1}{6}$ of the area of cross-action of the cupola at the melting zone.

A check on the volume of air was instituted, this being more important than the pressure. The ratio of the volume of air to the weight of coke used was the important factor.

For cylinder liners he aimed at the following analysis:—C.C., 0.8; T.C., 3.2; Si, 0.93; Mn, 0.8; S, 0.1, and P, 0.2 per cent.

A typical charge consisted of:—

| Cwts. | Material. | Composition. Si | P | Mn |
|---|---|---|---|---|
| 2 | Steel scrap ... ... | 0.30 | 0.06 | 0.35 |
| 2 | No. 2 Scotch ... ... | 2.3 | 0.4 | 1.0 |
| 1 | No. 4 Hematite (High Mn) ... | 1.4 | 0.03 | 2.1 |
| 2 | Cylinder scrap ... | 0.93 | 0.23 | 0.6 |

This gave an actual analysis of C.C., 0.85; T.C., 3.19; Si, 0.95; Mn, 0.7; S, 0.11; and P, 0.18 per cent.

As regarded the phosphorus content and its relation to the Brinell hardness, it was well known that high phosphorus irons gave a high Brinell figure, owing, of course to the phosphide being a hard brittle constituent. This fact was taken advantage of in making certain castings for sugar cane crushing rolls, but where strength and resistance to high temperature was required the percentage of phosphorus must be low.

MR. J. R. HYDE agreed with all the speakers had said as to the Paper being an extremely interesting one. His firm had just put down a Diesel engine. He paid particular attention as to what was going on in the foundry. Engines for some mysterious reason did seize up, and the foundry had a great deal to do with the success or failure of these things. He only wished that foundrymen could get a little more credit for what they did, and particularly from those in the drawing office. The success of the Diesel engine turned on the success of the iron in the foundry. Curly graphite had been referred to, and the lecturer said it was a thing to get if possible. What were the best conditions of producing this? He did not agree with quite a number of things the lecturer had said. They were running up to 1 lb. per sq. in. By changing the coke they would get entirely different results from the same mixture.

Unfortunately the whole of the work they had done had been upset by the coal strike. It was said that tests had been made up to 17 tons to the sq. in., and he was not exaggerating when he said they had got up to 20 tons to the sq. in. in Sheffield. He did appreciate the American idea of oil quenching. The theories as to the wear of cast iron were very interesting. A good many of them had been wondering why they did not use steel and so find Sheffield something to do.

MR. RICHMAN, answering Mr. Hyde, said in reference to curly graphite, the conditions seemed to be low total carbon and silicon content, with a fairly short cooling range. One of the inherent qualities claimed for cold blast iron could be traced to curly graphite. The only other way, and a cheaper way, was the use of steel scrap; they found this invariably gave a fine curly type of graphite.

The blast pressure cited by Mr. Hyde must be considered in conjunction with the tuyere area, which when small demanded a high blast pressure to obtain the correct volume into the cupola. It was quite possible to have too low a volume with a high blast pressure. As he had already said, pressure was a secondary consideration; it was the volume that mattered. He quite agreed with Mr. Hyde about unreliable coke; they could not produce good iron with bad coke.

MR. ROXBURGH said one point which surprised him was casting the cylinders on the flat, and he would like Mr. Richman's reasons for so doing. They had produced an iron with silicon 3.5 per cent. and a T.C. 2.4 per cent., using steel scrap and ferro silicon. He quite agreed with the speaker as to blast pressure, and 8 oz. was what they found was the best practice with a controlled and definite volume. The castings being produced

in the low T.C. iron were small flat plates ½-in. thick.

MR. RICHMAN, replying, said that casting cylinders on the flat was a question of producing a good casting as cheaply as possible. Foundrymen would realise from studying the design of the cylinder that it would be a very difficult and expensive way of producing this casting. All Diesel A frames were so cast, but if the liner and cylinder were cast as one casting then the job would certainly have to be cast vertically.

For the low T.C. iron, which Mr. Roxburgh was producing, practically the Emmel process, one must take into consideration the type of casting to be made was being used, but if he made a casting from a difficult design, having varying thickness, he would encounter shrinkage trouble.

A point which helped the low T.C. was the high S; it was easier to produce a low T.C. with high S than with a low Si. In producing an iron such as they were producing all the conditions favoured the absorption of carbon.

A MEMBER asked what difference was there between the pearlitic iron the speaker had shown and Lanz Perlit iron, and did a warm mould help to eliminate shrinkage trouble, and could the speaker explain why this should be?

MR. RICHMAN said that in his opinion there was no difference between the pearlitic iron shown and any other iron having a pearlitic structure. As long as the structure was wholly pearlitic it did not matter what method was adopted to produce it. It was a fact that a warm mould would, when a low Si and T.C. iron was used in conjunction with it, give the least shrinkage trouble. The reason for this was not very clear, unless it was that a warm mould gave a slightly prolonged solidification range, a sort of hesitation between liquid and solid, thus giving the iron time to take its shrinkage.

A MEMBER said he was surprised the speaker found that the runners of the liners were mottled and the casting grey.

MR. RICHMAN said when producing a pearlitic iron it was a fact that the mass of the casting produced must be taken into consideration with the analysis of the iron used in that casting. An iron suitable for a liner having a 2-in. wall thickness to be produced in pearlitic iron would be much too hard for a casting, say 12-in. × 1-in. × 1-in. test bar, and so it was in this case of the down runner on the liner. The mass effect caused the liner to be grey, and the lack of that mass effect caused the down runner to be mottled. To obtain a 12-in × 1-in. × 1-in. test bar, to represent a liner casting, the bar was cast alongside, and within ½-in. of the edge of the casting, so that the mass effect of the metal in the liner was exerted on the test bar, and so a grey bar was produced.

## Steel Foundry Receives Orders for Cement Plant.

Messrs. Edgar Allen & Company, Limited, of Imperial Steel Works, Sheffield, have received from the Oxford and Shipton Cement, Limited, an order for the plant for the production of 120,000 tons of Portland cement per annum at the new factory which is being erected in Oxfordshire.

The Southern Portland Cement, Limited, which is about to equip a Portland cement factory at Berrima, New South Wales, has also placed the order for their new plant with this concern, through their agents, Messrs. Noyes Bros. (Sydney), Limited. The capacity of the plant will be 120,000 tons per annum of high-grade Portland and quick-hardening cement.

Additional contracts which Messrs. Edgar Allen & Company, Limited, have in hand are a 50,000-ton Portland cement plant for the Milburn Lime & Cement Company, Limited, New Zealand; a 35,000-ton Portland cement plant for the Barnstone Cement Company, Limited, near Nottingham; a 35,000-ton Portland cement plant for Mr. W. E. Benton, Chinnor, Oxfordshire; and a rotary cement kiln and auxiliary plant for the Sundon Works of the Associated Portland Cement Manufacturers, Limited.

## Wet Process of Vitreous Porcelain Enamelling.—II.

By W. MARSHALL.

### Dressing Room.

This can be of considerable help in ultimately perfecting the finished article. It is desirable to grind off all fins and gates in a manner that will leave a clear casting without ridges or recesses. The operators in this room should be taught to grind the surfaces in such a manner that there will be no lumps, indentations or other defects, even blow- and draw-holes can be minimised by grinding. It should be remembered the enamel follows the surface and will carry the casting defect through to the finished job. Polished surfaces are not desirable on surfaces to be enamelled, as the enamel will not adhere well to polished cast iron, and, moreover, it is labour lost, as the surface is roughened again in the sandblast operation. Care must be taken to avoid the use of acids in cleaning castings, and they should be strictly kept away from all oil or any such substances which will cause trouble in the enamelling operation. The iron is porous and will absorb acids, oil and other foreign matter, which will vaporise and produce bubbles and also cause the enamel to fly from the casting during the burning operation.

### Sandblasting.

Castings to be porcelain enamelled must be thoroughly cleaned and free from sand and grit. This is best accomplished by sandblasting. If proper equipment is used, and due regard paid to the air pressure and abrasive, very little or no trouble will result from this source. However, enamellers must not lose sight of the importance of this operation, and strict control must be exercised at all times. The sandblasting operation should be done with fine flint; experience here seems to indicate that shot abrasive peens the surface of the casting much more than flint, and, therefore, destroys those infinitesimal hooks, hollows and humps that should be on the surface to fuse into and help to bind the enamel. Do not rattle castings to be enamelled (by this is meant barrelling), the sandblast will clean them, and long barrelling is likely to affect the surface the same way as blasting with shot.

There are several makes of sandblast equipment on the market suitable for porcelain plants; the writer, however, is of the opinion that the free blast in conjunction with a chamber or cabinet gives better all-round results than the automatic machines. Sandblast equipment must be kept in good condition; it should be inspected frequently, all air lines should be equipped with oil and water separators, and the air pressure at the sandblast machine should not be less than 60 lbs. per sq. in.—80 lbs. per sq. in. will give better results. Efficient sandblasting will go a long way towards keeping the enamelling costs low, and will avoid the redoing of work which results from dirty castings. Many attempts have been made to use a substitute for flint but with indifferent results, and from the writer's experience the use of the best flint sand will be the least expensive in the end. Sandblasting of cast-iron castings is analogous to pickling sheet iron before enamelling; good sandblasting gives a silver grey appearance, associated with a rough surface, thus exposing the pores of the iron, which results in better adherence of the enamel.

When a casting is fired the pores of the iron naturally expand, and if the surface is clean the enamel will hold perfectly. It is difficult to remove oil and grease from castings that are to be enamelled, and where this condition exists castings should be annealed before sandblasting. This will burn out the oil or grease and the desired surface will be obtained after sandblasting. Imperfect sandblasting will result in "jumpers" and black specks. The castings will then have to be re-sandblasted and re-enamelled, and it very often happens that this trouble does not appear until the second coat of enamel has been fired. The sandblast operation is necessarily a somewhat dirty one, and this department should be located where as little dust as possible will enter the other departments. The sandblast room should be detached from the enamelling building, if possible, and connected to the spray rooms by a covered runaway. Castings should be sprayed as soon as possible after sandblasting. If there should be any delay the sandblasted castings should be stored in a dryer, or at least in a place where they will absorb as little moisture as possible. In conclusion, the writer is convinced that many of the troubles that occur in the wet process of enamelling of cast iron are blamed on the foundry, and to many causes other than sandblasting; but a very careful check of cast-iron enamelling in this country has indicated that the majority of the troubles are caused by poor sandblasting, and as a precaution the writer would suggest that the enameller examines the sandblasting outfit before looking for the trouble elsewhere.

## Notes on Oxy-Acetylene Cutting in Foundries.

By C. H. S. TUPHOLME.

The proper use of the oxy-acetylene cutting flame has enabled many foundry managers to reduce their rejections, and the flame, when employed for cutting risers, has exerted an important influence on modern casting practice. Manganese steel castings afford an instance of the use of the oxy-acetylene flame, which has replaced other methods for removing the sprues and runners or the risers and sink heads. Though manganese steel offers almost insuperable obstacles to other cutting methods, it can very readily be dealt with by the oxy-acetylene flame.

In the case of carbon steel castings many foundries are now using the flame instead of the sprue cutter on small castings and the "flogging" method on large castings. Many foundries still use the saw for cutting risers up to 3 in. or thereabouts in thickness, though the gas flame has in many cases proved much more economical.

The gas flame is not so often used in cutting risers from grey iron castings, because the metal is more brittle and softer, and the sink heads may be broken or sawed off easily. There are cases, however, where the cutting flame is useful, *e.g.*, in the case of large cast-iron roll housings.

The cutting flame may play an equally important part in the reclamation of defective castings, particularly where the defect is minor in degree, such as a blow-hole, a shrinkage crack or part of a lug missing. An instance of the economy which may be effected is afforded by the case of a foundry producing brass castings for faucets and general pipe fittings. The records showed that 95 per cent. of the castings made were good, and that the use of the oxy-acetylene flame enabled over 3,000 reclamations to be made per month on an average at a cost of just over half the replacement cost. It is worth noting that all these reclaimed parts had to pass a rigorous hydraulic test and were also nickel-plated afterwards, so that the welder's work had to be perfect.

Another opportunity to use the flame for reclamation is in the case of aluminium castings. The three methods of reclamation that have been used for aluminium castings are burning-on, *i.e.*, adding metal to fill up the defective section; soldering, which has not proved successful; and oxy-acetylene welding. In an investigation covering a number of foundries made by Anderson and Boyd, of the American Foundrymen's Association, the following figures were the result:—

| Production. | Total castings poured. | Passed first inspection | Castings saved by welding. | Total rejects. |
|---|---|---|---|---|
| Miscellaneous automobile .. | 2,093 | 1,018 | 808 | 267 |
| Motor crank cases | 502 | 270 | 214 | 18 |
| Differential housings .. | 438 | 242 | 96 | 100 |
| Jobbing foundry | 100 | 92 | 5 | 3 |
| Motor castings .. | 100 | 89 | 12 | 4 |

From such figures it would seem that half the castings which would be rejected could be reclaimed by welding.

It is obvious that a large and complicated casting should be welded rather than scrapped if a small defect should appear. Instances of this procedure are to be found in large motor-car works, where, in many cases, the welding of crank cases, grey iron cylinder blocks, transmission covers and pistons is the regular practice.

# Oil Sand Cores in the Jobbing Foundry.*

By J. Masters.

The author lays no claim to a new practice when bringing this subject before the meeting. There seemed to be no definite information available as to by whom and when this method was introduced, and no credit had been claimed for what had undoubtedly been a great boon to foundrymen.

During the war the output of thousands of tons of ferrous and non-ferrous castings had been made possible by the use of core oils. It was not proposed to discuss the merits of any particular core oil. Many claimed to have the "one and only" mixture, and there was no doubt that during the past ten years much progress could be recorded, the present-day result being that it was possible to make practically any class of core with the aid of an oil binder and silica sand.

Up to the present it had not been found commercially possible to produce a binder which would take the place of loam such as is used in the manufacture of pipes or large loam moulds. Research work was being carried on to provide a sand free from any opening matter. Those who had this matter in hand were rather conservative as to its composition, but he thought before long there would be a binder on the market which one could "slip" as easily as core loam.

It had, however, been found economical to form core prints where possible and to use cores in places where there were brackets, feet, flanges or overhung pieces in the moulds made in loam and by building the cores in the moulds.

Everybody remembers the variety of commodities used as binders, *i.e.*, glue, treacle, flour, beer, various kinds of gums, boiled potatoes, resin, etc., with results as varying as the materials themselves. At times cores would be removed with ease, but at others the greatest difficulty was experienced, notwithstanding the fact that, as far as it was possible to judge, the mixtures had been the same in each instance, and the reluctance of many foundrymen to try oil sand cores was, in many instances, due to the adverse reports which had been circulated.

### Baking Cores.

Sea-shore sand was the most used, and when easily obtainable it was undoubtedly the best. There were in many parts of the country local deposits of sand which gave satisfactory results. All that was necessary was to find a suitable sand, suitable binder, and use a little tact in manipulation, and last, but not least, to have proper drying or baking facilities. The baking was as essential as the binder, and there must be reasonably controllable conditions. There was no doubt that many foundries had paid very little definite attention to the drying of cores and moulds. It was essential to know at what temperature to dry the cores, but after a little experience this became automatic. Definite temperatures were sometimes given by certain firms, and the danger of burning the cores could not be too strongly emphasised. The most important factor was to get the temperatures to about 250 to 300 deg. Fah., and to do the rest by passing in free hot air.

In all jobbing foundries there would be a certain amount of dry sand moulds which would have an effect upon the oil sand cores, but it was necessary to have a free passage of oxygen into the stove alongside the firebox and by this means a coke consumption of, say, five cwt. per night easily be reduced to one of three cwt. per night. It was very surprising to see how accurate some foundrymen became in the matter of temperatures without the aid of pyrometers, but the danger of burning cores could not be too strongly stated.

### Co-operation Between Foundry and Pattern Shop.

Much time and money might be saved by practical co-operation between foundry and pattern-shop foremen. Often economy could be effected by parting a core into two or three pieces, obtaining perfect results. In the case of valves or castings of a similar character, it was necessary to make only half of a box, and where jointing of the core was necessary this could be done by drying one half, then placing the green half on the dried half for carrying into the stove. For example, a 12-in. stop valve could quite easily be made in halves, but above this size one need not joint. Again, where the bottom of a casting—a bedplate, for instance—had to be made with a checker or diamond pattern on the bottom, all that was necessary was to make a block print, say 1½ or 2 in. thick, and a section of corebox, say about 18 in. long or as near as is practicable to meet the design of the pattern. This method was, said the speaker, adopted in many large foundries in Lancashire and Yorkshire, one great advantage being that a mould with a dry-sand bottom and green-sand wall was obtained.

### Avoiding Unsightly Markings.

In cases where it was necessary to fasten studs on the sides and bottoms of moulds, oil-sand cores were of great assistance. This refers to green-sand moulds. If it was necessary to put a stud in position, it was possible to locate it better, and there was no risk of unsightly marking. All that was necessary was to put a flat piece of core to the face of the pattern and ram up in position ready when the mould is finished to have the studs or chaplets fixed on with tacks or small nails. Properly made slabs would resist moisture and also stand heavy weights without yielding. If given a good coat of blacking there would be no marks left on the casting.

### Blacking Cores.

So far as grey-iron castings were concerned, the chemical composition of the sand was not the serious factor which many foundrymen seemed to think it was. For castings other than grey iron, more care should be exercised, and in many cases it would be found advisable to blend two kinds of sand together; and where high temperatures were to be encountered, it was essential to blackwash the cores to resist the erosion of the metal. For castings with a fair percentage of tin or phosphorous content blacking was a good factor of safety, and for malleable castings various methods were adopted. In some cases three varieties of sand were used in conjunction with the binder compounds.

### The Venting of Cores.

Vents were recommended as a safeguard, but the use of wax vents was not recommended, as these leave a soft area in an oil sand core due to the carbon compounds from the wax taper. Strands of straw made good vents, and when the cores were baked the ends of the straw could be located by just filing a small ricket along the print of, say, a port core and, providing the metal is not allowed to get over the print of the core, the gases come away readily with a minimum amount of trouble. In many instances vents were unnecessary, and in the making of large cores it was not necessary to use any special method of venting. Large bulky cores were readily made by just lining the walls of the core with oil sand and filling the inner part with cinders, clinker or old black sand. This, undoubtedly, is a very efficient method, as it keeps the dressing shop free from a lot of undesirable matter, added to which it is readily removed from the most intricate castings, and as soon as the casting is in a position to be dressed the cores run out if a free escape is provided.

### Core Irons.

With oil-sand cores, grids and core irons are reduced to a minimum. For instance, large wheels could be made with oil sand which by loam-sand method would need grids to carry the sand and also for lowering the cores into the mould. With oil sand all that was necessary was a few loose irons with one placed in the proper position to carry the lifting hook. Wheels weighing 12 tons had been made where every core was oil sand and not a single grid was used.

One of the chief economies in the use of oil-sand cores would be found in the dressing shop, and it was safe to say that wherever oil sand was used, the one class of foundry worker who liked this class of core was the dresser.

### Stator Frames.

The mould for this was struck up in loam. The core was made partly in loam and then built up by segment cores made in oil sand. In making this a dummy core was built up on a plate and the sand mixture was 80 per cent. silica and 20 per cent. red sand, very similar to that known as Manchester Ship Canal sand. The method adopted was to strike a central dummy and at definitely arranged places these cores were made in 20 segments—that is 80 segment cores in two segment boxes. The boxes were modified to allow for the difference in the flanges. The oil-sand cores were first given a good coat of blacking, and when assembled in position a second coat of blacking was applied. The internal diameter of casting would be about 9 ft., and about 10 ft. 9 in. at the feet. The panel cores acted as a setting piece and these had only ⅛-in. clearance. The branch cores were all oil-sand and gave no trouble.

### Turbine End Casting.

This casting, weighing some 5 tons, represents a casting of complicated character which called for much care in making. The sections varied considerably and some attention had to be paid to the question of contraction. Every core was made with oil sand and the use of a sand which carried a certain amount of bond and of high silica content, actually a mixture of sand containing 80 per cent. sea sand was used. In a casting of this description, unless very liberal allowances were made for contraction, there was bound to be trouble. All these castings had to pass a tensile test of 13 tons. Core irons had to be eliminated as much as possible. For electrical work, the bearings had to be quite sound and free from blemish. Four grids were used in the body core and the core was lifted from the top grid, the series of grids being bolted together.

### A Cylinder Casting Mould Made in Loam.

Every core, except the body core of this casting was made in oil sand. The casting weighed 5 tons 17 cwts. The centre core was built up in loam and called for a very good mixture of sand. Pure plumbago was rarely used on dry-sand moulds. For blacking purposes a mixture of mineral blacking and about 30 per cent. plumbago together with the use of a very thin clay wash, whilst sometimes a little oil was added to the blacking.

There was no real danger in using the same stove for drying oil-sand cores as well as loam, but oil had been found deposited on the loam moulds in stoves where they and oil-sand cores had been dried together. The trouble was that insufficient air had been allowed to pass through the stove and an improved draught corrected matters.

Gear-reducing units, weighing 8½ tons, were also made in oil-sand cores. In rubber-crushing plant the large couplings are cast with Ronceray runner, whilst the rollers are cast vertically with a 40-per cent. steel mixture and made in moulds consisting of a mixture of loam sand with oil bond. The roller-body core was struck up on a barrel and every other core was made in oil sand. The weight of this was approximately 40 tons, without motor.

For rubber-forcing machines, as used for motor tyres, the body core is in two pieces forming an oil bath for change gears and the vent is brought through two 2-in. holes in the bottom of the mould. A large bedplate, which had had 140 cores, all made of oil sand. The fettling costs had been reduced over 40 per cent. after the first casting was made, this first casting having been made with ordinary loam-sand cores. Each casting weighed about 15 tons 16 cwts. Trouble had to be overcome due to contraction stresses and also in securing cores in the mould and elimination of lift. Special grids were made for the top cores and supplementary runners were formed in cores to assist the flow of metal and reinforce the top and bottom plates. During the process of cooling in the foundry, these supplementary runners all cracked in about the same place. The castings were left in the floor where made for 14 days after being cast and the dimensions were 16 ft. × 8 ft. × 5 ft. of box section and were tested 40 lbs.

* A Paper read before the Wales and Monmouthshire Branch of the Institute of British Foundrymen at Newport, Mr. Ben Hirst presiding. The author has presided over the Lancashire Section.

# The New Railway Rates—Effect Upon the Foundry.

By J. W. Parker, A.M.Inst.T.

After some half dozen years' investigation the long-expected changes in the railway rating system will materialise on January 1 next. These alterations affect almost every part of the rating structure, although at the outset no very extensive changes in the general level of charges will be noticeable. In individual instances, however, charges will differ owing to the extension of the classification and restrictions upon exceptional rates. The new classification, so far as it concerns the foundry trade, may first be considered. The existing eight classes will be replaced by twenty-one sections in the following manner:—To-day's Class "A" will become the new divisions 1-2, "B" will be spread over Nos. 3-6, whilst "C" is to be split up amongst 7-10. Existing class one will become 11-13, and two is to be given over to 14, 15 and 16. New numbers 17 and 18 take up the position of to-day's No. 3, whilst 4 and 5 are to be the new 19 and 20. No. 21 is a fresh departure, having no equivalent in to-day's volume. The new numbers will doubtless be found more familiar if illustrated by their application to some foundry trade commodities. Founder's dust is to be removed from "C" to 9. Moulds, will be in 13 instead of 1, and scrapings from brass furnace fireholes will be in 5 instead of "B" as will also fireclay blocks. Furnace rakes now in 1 will be found in 13, but moulders' boxes, at present in the same division, will be two classes higher at 13, thus showing the latitude of the new classification. Patterns for castings are to be in 19, but in 18 when returned after use to the makers. A similar variation is apparent in castings. Those of aluminium or nickel will be in 18, whilst those of brass, bronze or copper will be in 17, whereas to-day they all come in No. 3. Iron and steel of an undamageable nature when consigned straight from the mould will qualify for 8. If they do not satisfy this stipulation they will be in 10, but if they have been machined, they are charged as machinery, the classification of which will be mentioned later. Light iron or steel castings packed in casks, crates or hampers, are to be in 13, but if not packed they will have to pay Class 17 rates. No. 10 is the appropriate division for malleable iron castings.

### Foundry Raw Materials to be in 6-Ton Lots.

Of equal importance is the increased minimum wagon load requirements imposed by the new classification. To-day the mineral divisions (A and B) call for minimum truck loads of 4 tons, but the new numbers 1-6 are for loads of six tons. This means a 50 per cent. increase in the wagon load for fuel, pig-iron, gannister, sand, scrap, etc. For the equivalent of Class "C" the increase is 100 per cent. at 4 tons, except in the case of No. 10, which still retains the original two tons minimum. The present numbered classes are free from truck load stipulations, but now No. 11, which is one of the equivalents of to-day's Class 1, will necessitate consignments of 2 tons to secure the lowest rate. The effect of this requirement upon, say, moulders' boxes is that unless 2 tons are forthcoming, Class 12 rates instead of 11 will become chargeable. The general rule as to the weights for less than minimum quantities is set out in Table I.

TABLE I.—*Classification when less than minimum load.*

| Minimum load. | When tendered in loads of not less than 4 tons. | Chargeable class. | Tendered not less than 2 tons. | Smaller lots. |
|---|---|---|---|---|
| 6 tons .. | Class 7 | Class 10 | Class 10 | Class 12 |
| 4 tons .. | — | — | Class 10 | Class 12 |
| 2 tons .. | — | — | — | Class 12 |

As has been mentioned heavy iron and steel castings when machined are charged as machinery under the following arrangement:—

| | |
|---|---|
| In 5 ton lots ... ... ... | class 12 |
| In 2 ton lots ... ... ... | ,, 14 |
| Less ... ... ... ... | ,, 16 |

The requirements as to minimum wagon loads have been stressed, because in many instances trade has been built up upon the basis of present stipulations, hence any change in this direction may call for an alteration of policy unless economy in transport costs is to be at a discount.

To-day any article not classified is charged in division 3, but in future it will be placed in class 20, an increase of two divisions judged by the existing basis. This will, of course, chiefly concern new varieties of goods and pioneer efforts generally.

### Railway Standard Revenue.

Present-day rates are governed by the principle of maximum charges laid down by Parliament, within which the railways have a considerable discretion, but beyond the prescribed limit they must not go. All this is to be changed in favour of the new principle of "standard revenue," whereby a certain fixed sum is authorised to the railways, rates and fares being so adjusted as to yield this sum precisely. The duty of securing "standard revenue" does not fall to the railways themselves but to a court specially set up for this and other purposes of the Railways Act, 1921. The Court, which is known as the Railway Rates Tribunal, comprises two members, a lawyer, who is chairman, a railway expert and a business man. The last-named represents a concession to trading interests, which it is recognised are entitled to have a share in determining what shall be paid for rail conveyance. On the other hand, trade has now a definite responsibility towards the railway, for, upon the Tribunal rests the financial success of the various lines. Many other duties devolve upon the Tribunal, such as the institution, variation or cancellation of group rates, alterations to the classification, amounts to be allowed for terminal services, packing regulations, etc. The Court's jurisdiction does, in fact, cover almost the whole of the commercial relations of the railways and their customers. To enable it to be available to any trade with a legitimate business, it is provided that in proceedings before the Court costs shall not be awarded unless any particular case is deemed to be frivolous or vexatious. Furthermore, upon questions of fact the decision of the Tribunal is final, only upon points of law can rulings be sought from a higher court. The effect of these enactments is to make the Tribunal the recognised body for the settlement of most difficulties likely to arise between railways and railway users. Hitherto, the tendency has been for business to continue to suffer hardship rather than incur the heavy expense of a legal action in the usual way. The Tribunal will, of course, charge fees, but these are of a very reasonable nature.

### No Increase in Mileage Rate After Transference.

One of the most important duties so far undertaken by the Court has been the examination and approval, in December last, of new schedules of class or "standard" rates governing the 21 divisions of the revised classification. The new schedules are common to all the group companies. When it is realised that more than 30 different schedules are in force to-day, the gain in the direction of simplicity will be acknowledged. In the opinion of the Tribunal, the revised schedules preserve relativity with existing lists, except, of course, where the modifications inseparable from eight additional classes are concerned. There is one other exception, and that is charges upon long distance goods are comparatively lighter than upon short haul traffic. Two factors account for this; they are "continuous mileage," and the reckoning of distances over the shortest working routes. To appreciate the former, one must understand that rates are constructed upon the "tapering" principle, that is, the charge goes progressively less as the distance increases. Where, for example, the charge for the first 20 miles is 3.65d. per ton, for the next 30 the amount is reduced to 2.55d. At present when goods pass from one railway to another, the rate begins afresh at the amount for the first 20 miles, that is, at the highest possible figure; but under continuous mileage, no such break is made, the rate being made up as if the entire journey were over the line of one company.

The railway amalgamations of 1923 and previous years resulted in a number of shorter working routes being made available so that a reduced charge in various instances will be the result. In the other direction short hauls appear to have their rates increased as the "flat" rate, now a separate figure, becomes embodied in the first 20 miles of the revised schedule so that its full weight apparently falls upon short distances.

### Exceptional Rates Decreased.

As is known, the great bulk of goods are carried not at class charges but under exceptional rates. Extensive limitations are to be put upon these reduced charges, as the Railways Act requires such rates as are less than 5 per cent., and not more than 40 per cent. below the corresponding standard rate to automatically lapse as from January 1 next. Whilst the standard rates may not be particularly useful in themselves they do become valuable as a means by which exceptionals can be measured. The original intention of the Railways Act was to make a sweeping reduction in the number of exceptional rates; indeed, this was the primary object of the extended classification. It was thought that by introducing new classes at the points where exceptional charges were most plentiful would eliminate a large quantity of them. Subsequent experience has proved the impossibility of this intention, and there is every prospect of the new system coming into force with exceptionals only reduced to 60 or 65 per cent. of to-day's total.

A further restriction may be placed upon reduced rates, as if it is considered the railways are granting exceptional charges in such a manner as to jeopardise the attainment of standard revenue, either the latter amount may be revised or the offending figures be cancelled. Another new proviso gives the trader authority to ask the Tribunal to fix a new exceptional rate for him. Hitherto the railways have had complete discretion to grant or withhold a lower quotation, a state of things which the individual business man has often felt to be unfair. As yet, it is not clear whether this privilege will always be of advantage to business because the Tribunal's attitude towards exceptionals must necessarily be determined by their responsibility to "standard revenue." If easy of attainment, doubtless the Court will be generous, but if the revenue is difficult to obtain the railways may grant better quotations. In any event the trader who obtains a quotation fixed by the Tribunal will have a more permanent figure because the railways can withdraw their own concessions at thirty days' notice, but they cannot interfere with those rates issued by the Tribunal.

### Station to Station; or Collection, Transit, and Delivery.

From time to time charges will be examined by the Tribunal in the light of whether or not they are producing the correct amount of "standard revenue," and if a surplus or shortage is discovered, charges will be adjusted to redress the balance.

As an inducement towards economy and efficient working upon the railways they will be allowed to retain up to one-third of the amount saved. Up to now the amount yielded from this source has been comparatively small, but, no doubt, the future will see a substantial increase.

Comparison between old and new rates is somewhat difficult, as the new figures are upon a station to station basis and not "collected and delivered" as are to-day's figures. Industry is sharply divided as to the desirability of this change. Heavy trades prefer the "S. to S." charges, as there is then no risk of being charged for services not performed by the railway, but the lighter trades prefer the convenience of a single rate covering collection, transit and delivery. A compromise has naturally ensued whereby the railways have agreed to continue a number of existing C. and D. figures.

## Trade Talk.

A FIRE, attended by considerable damage, broke out at the works of Kynoch's, Limited, Lion Works, Witton, recently.

THE BRITON FERRY IRONWORKS, which have been closed down for about six months owing to trade depression, are to resume operations in the New Year.

ABOUT 100 MEMBERS of the Newcastle Branch of the Institute of British Foundrymen visited the Palmer Company's blast furnaces on Saturday and were afterwards entertained to tea by the firm.

MARSDEN & NAYLOR, LIMITED, engineers, Skipton, have disposed of the goodwill of their power transmission department (including patterns, drawings, etc.) to Williams & Womersley, of Ings Foundry, Wakefield.

THE POSSIBILITY of safeguarding the iron and steel industry was discussed at a meeting of the 1922 Committee of Conservative members on December 12, when the speakers included Sir William Larke, of the National Federation of Iron and Steel Manufacturers, Mr. C. D. Whitehead, and Mr. H. C. Bond.

GALLOWAYS, LIMITED, Knott Mill Iron Works, Manchester, have acquired the goodwill, patterns and drawings of John Musgrave & Sons, Limited, Globe Iron Works, Bolton, and with them Galloways, Limited, are receiving the drawings of engines formerly made by John and Edward Wood, Bolton.

BRITISH INSULATED CABLES, LIMITED, of Prescot, Lancs., have received an order from the Central Electricity Board for approximately 228 route miles of 132 k.v. 3 phase, overhead transmission lines in Scotland. The materials are to be supplied from within the British Empire, and include approximately 1,000 miles of steel cored aluminium conductors, and 1,500 steel towers. The value of the order is approximately £400,000. This is the largest single order for such work ever placed in this country.

SIR ALEXANDER M. KENNEDY, chairman and managing director of the Fairfield Shipbuilding and Engineering Company, speaking after the launch of the motorship *Taranaki* for the Shaw, Savill and Albion Company, from the Fairfield yard recently, referred to the suggestion of the Duke of Montrose for a pool of shipbuilding interests. Of shipbuilding in the broad, he said, he did not see on what basis there could be any room for general amalgamation.

THE CRITTALL MANUFACTURING COMPANY, LIMITED, have taken a half-share in the Darlington Rolling Mills Company, Limited. Modern mills will be installed for the purpose of rolling special sections. The Darlington Rolling Mills Company will be reconstructed in due course. The works were started in 1866, and though the concern has had its vicissitudes, its continuity has never been broken. Some time ago the mills were modernised by Bolckow, Vaughan & Company, who acquired the ordinary share capital.

DURING THE PAST few days contracts to the value of over a million pounds sterling have been given to International Combustion, Limited, whose works are at Barrow-in-Furness. These include a contract for the largest boiler house plant ever yet projected in Great Britain to operate at 800 lbs. working pressure. They have also secured three further contracts, a repeat order for Shanghai Electricty Department, and another for the Leeds Corporation, where for the new super-power station the "Lopulco" system has been selected for the complete boiler house.

THE RT. HON. W. C. BRIDGEMAN, M.P. (First Lord of the Admiralty) has promised to perform the opening ceremony at the Fourth Machine Tool and Engineering Exhibition, which is to be held at Olympia, September 5 to 22 of next year. It is quite evident that the exhibition is going to be a great success. Already the whole of the main hall and nearly the whole of the annexe have been booked by exhibitors, and a considerable part of the gallery is also let. At no previous Exhibition promoted by the Machine Tool Trades' Association has so much space been let ten months before the exhibition is due to open.

## Obituary.

MR. CHARLES HALEY, head of the firm of Charles Haley & Company, ironfounders, of Bradford, djed recently.

MR. THOMAS FENDER, a former director of Vickers, Limited, died at Purley last week at the age of 63. He entered the service of Vickers, Limited, at Barrow in December, 1901, and later, after acting as superintendent over the whole of the works, he was elected a director, retiring in 1925.

## Company Meeting.

The twenty-ninth annual meeting of the South Durham Steel and Iron Company, Limited, was held on Wednesday at Middlesbrough.

THE RIGHT HON. VISCOUNT FURNESS (the chairman) presided, and, in the course of his remarks, said:—The financial year through which we have just passed may be regarded as abnormal seeing that our steelworks were practically idle during the first three months, owing to the national coal strike.

With regard to the balance-sheet plant account stands at a low figure, the net additions during the year amounting to £38,719, the greater portion of which has been expended on our steel pipe department. As you are aware, during the last four years we have established the new pipe works and galvanised sheet works at Stockton. The capital cost of these, together with the requisite working capital, has been provided out of the company's resources, and this item, together with the capital expenditure at our steelworks, and investments total over £500,000. Stock-in-trade amounts to £393,519, as against £266,838 last year, an increase of £126,681, which is now being steadily reduced. During the year Government securities of a nominal value of £250,000 have been sold to provide for the additional capital requirements. The profit on the sale of this stock has been utilised for writing down the price at which the remaining securities stand in our books.

Referring now to the profit and loss account, the amount brought forward at September 30, 1926, was £161,596, which, after the payment of the dividend on the preference shares, and a dividend of 1s. per share on the ordinary shares for the year ended September 30, 1926, left a net figure of £139,596. The profit for the year under review, after adding £52,664 from special reserve account, amounts to £97,044.

I have referred to the fact that our steelworks were practically idle during the first three months of our financial year. As you all know, the consumption of steel plates is largely dependent upon shipbuilding, and in consequence of the steelworks being shut down for six months last year, specifications during the first half of 1927 were plentiful, as steel was urgently required at the shipyards and engineering shops, which, in turn, had been almost entirely closed during the strike period. The arrears for shipbuilding and general engineering requirements were, however, soon overtaken, and the demand now is such that there are too many plate mills in this country for economical employment.

There is no doubt that in this country we are not developing the uses of steel to the same degree as other steel-producing countries. In America, which is a timber-growing country, practically all rolling-stock is now built of steel, while we, as a timber-importing country, build most of our wagons of wood. I would urge upon our railway companies seriously to consider this matter, especially having regard to the fact that they would derive the revenue on six tons of traffic—including the raw material—for every ton of steel used in connection with the construction of such wagons. In view of the increasing production of steel in foreign countries and all parts of the British Empire, where the necessary raw materials are available, many of the markets hitherto supplied by British manufacturers will in future be considerably affected. It is, therefore, obvious that the home market of each country, including our own, will become a question of increasing importance.

If we could manufacture the whole of the iron and steel required in this country, and export even at the same rate as in 1913, work would be available for a productive capacity of over 11,500,000 tons of ingots per annum, which is practically equal to the full productive capacity of the industry, but this is impossible so long as we are content to allow Continental steel manufacturers to send their products into our home markets.

The Board has reluctantly decided to concentrate for the time being on the production of steel plates at only one of our works, as it is not considered advisable from an economic point of view to keep the furnaces and mills at Stockton and West Hartlepool only in partial operation. Although both works have been kept in operation with the object of providing employment for our workmen, the Board, after very careful consideration, feel that present conditions render it impossible to continue this policy.

Many suggestions have been considered for closer working arrangements among steel manufacturers, and the question of amalgamation has again been brought forward prominently by the Government, the Press, and the chairmen of several iron and steel companies. A recent example is provided in the partial amalgamation which has been arranged in the armament and shipbuilding industries.

In this connection, I would refer you to my speech at the annual meeting of shareholders held in November, 1922, when I expressed the opinion that amalgamation of selected companies was desirable, and drew the parallel between our own position and that which existed in the United States of America prior to the formation of the United States Steel Corporation in 1900.

There is no doubt whatever that greater efficiency in manufacture and selling could be obtained by the combination of suitable works producing similar commodities.

## Reports and Dividends.

**Petters, Limited.**—Interim dividend on 7½ per cent. cumulative preference shares, less tax.

**North Lonsdale Iron & Steel Company, Limited.**—Dividend passed for year ended October 31; loss on year, £1,430.

**Richard Thomas & Company, Limited.**—Profits for year, £223,293; interest on debenture loans, employees' profit-sharing deposits and staff pension fund, etc., £150,719; depreciation and special expenditure, £61,944; brought forward, £179,117; carried forward, £189,747.

**Weardale Steel, Coal & Coke Company, Limited.**—Profit, £59,830; brought forward, £46,256; total, £106,086; interest on 4 per cent. debenture stock, £11,492; dividend, 6 per cent. per annum on deferred ordinary shares for year; reserve account, including depreciation, £20,000; carry forward, £31,094.

**R. & W. Hawthorn, Leslie & Company, Limited.**—Statement of accounts for six years ended June last: credit balance, £179,818; brought in from 1921, £36,275; available, £216,094; general reserve, £15,850; reserve for plant extensions, etc., £7,120; dividend paid from and including year ended June, 1922, to year ended June, 1927; carry forward, £17,568.

**Consett Iron Company, Limited.**—After providing for debenture interest, but not for depreciation, there is profit for half-year ended September 30. Having regard, however, to present uncertain conditions of trade, directors do not feel justified in payment of interim dividend. Dividend on £500,000 of 8 per cent. preference capital in arrear as from March 31, 1925.

## Contracts Open.

**Bamford, near Sheffield,** December 27.—15,000 yds. of steel pipes, 47-in. internal diam., ½ in., ⅝ in. and ¾ in. thick, for the Derwent Valley Water Board. Mr. S. B. Winser, engineer to the Board, Bamford, near Sheffield.

**Cairo.**—Two sets of 4-in. duplicate centrifugal pumps with all accessories; two 35-b.h.p. electrical motors; two 4-in. by 6-in. flanged sluice valves and reflux valves included in one semi-rotary 2-in. pump; 500 inner and 500 outer volute springs; and 10 steel fireboxes, for the Egyptian Government. The Chief Inspecting Engineer, Egyptian State Railways, Queen Anne's Chambers, London, S.W.1.

**Crossness, Erith,** December 23.—150 tons of cast-iron piping, etc., ranging in size from 24 in. to 12 in. diam., for the London County Council. The Chief Engineer at the Qld County Hall, Spring Gardens, S.W.1. (Fee £2, returnable.)

**Dublin,** December 20.—1,860 yds. of 9-in. turned and bored cast-iron pipes, for the Borough Commissioners. The Borough Surveyor, 28, Castle Street, Dublin.

**Eyemouth,** December 27.—Supply and fixing 960 yds. 4-in. cast-iron main, etc., for the Town Council. Hunter, Duff & Middleton, civil engineers, 42, Frederick Street, Edinburgh. (Fee £1, returnable.)

**London, S.W.1,** December 23.—(1) Pressed steel sleepers for B.S. 60 R.F.B. rails; and (2) compressed air mains, for the South Indian Railway Company, Limited, 91, Petty France, Westminster, S.W.1. (Fee £1 for each copy of (1) and 5s. for each copy of (2), non-returnable.)

**Manchester,** January 3. — (B. 60) Low-pressure auxiliary pipework, for the Electricity Committee. Mr. H. C. Lamb, chief engineer and manager, Electricity Department, Town Hall, Manchester. (Fee £2 2s., returnable.)

**Rochdale,** December 31.—Two mortar mills with pans of 7-ft. diam., for the Cleansing Committee. The Cleansing Department, Entwistle Road, Rochdale.

**Polish Ironmasters' Syndicate.**—A Commission is engaged on revising the existing agreement among Polish ironmasters, which can be determined on July 1, 1928, by three-months' notice. The revised agreement is to widen considerably the scope of the agreement in respect of exports.

# Iron and Steel Markets.

## Pig-Iron.

**MIDDLESBROUGH.**—It is, of course, now too near the holiday break to expect anything like active business in pig-iron, and, as far as Tees-side is concerned, both sellers and buyers are content to postpone dealings until the Christmas festivities have subsided. A significant sign of the trend of trade in the Cleveland area is, however, afforded by the statement that stocks of iron in makers' yards is a daily diminishing factor in the position, while shipments, on the other hand, already show a substantial increase on the figures for the corresponding period of the previous month. The still outstanding difficulty with which Cleveland iron ore is confronted is the recapture of the Scottish market. It is reported that Continental prices are again a little firmer, and the Cleveland makers have also made slight concessions, having recently sold iron f.o.t. Grangemouth at 68s., which is equal to about 63s. per ton at Middlesbrough. The significance of this lies not so much in the extent of the concession as in the restoration of a certain amount of elasticity in regard to Cleveland iron prices. In all markets except Scotland the price control exercised by the Ironmasters' Association is absolutely rigid, but if the makers are prepared to break prices in Scotland, it is argued that they cannot indefinitely refuse to do so elsewhere. Meantime prices are unaltered as follow:—No. 1 Cleveland foundry, 67s. 6d.; No. 3 G.M.B., 65s.; No. 4 foundry, 64s.; No. 4 forge, 63s. 6d. per ton.

The East Coast hematite section also shows some improvement at last, and at the moment consumption is in excess of demand. Prices having now reached lower levels, more attractive to buyers, have had the effect of inducing consumers in Sheffield, South Wales and even foreign markets to place orders, with the result that a more hopeful outlook has been created, favouring an early expansion of business. The quotation now ruling for East Coast mixed numbers is 71s., with North-West Coast Bessemer quality at a similar figure.

**LANCASHIRE.**—Consumers of foundry pig in this district are still disinclined to attempt forward buying, with the expectation of obtaining better terms early in the New Year, and business generally is quiet in view of the pending holiday stoppage. Variations in prices are few, the following representing current quotations:—Staffordshire, 72s. 6d.; Derbyshire No. 3, 73s. 6d.; with Cleveland at round 78s. and Scotch from 88s., all delivered Manchester or equal.

**THE MIDLANDS.**—At Birmingham of late there has been no change to report in the pig-iron section, with consumers generally postponing all new business until after the turn of the year. As regards prices, Northampton No. 3 is still on offer at about 60s., Derbyshire 65s., with North Staffordshire similar quality at 64s. 6d. to 65s., all furnace quotations.

**SCOTLAND.**—Demand for most makes of Scotch pig continues on the quiet side, but so far no further diminution of production is apparently anticipated. The price of No. 3 foundry is, however, again shaded, 71s. at furnace having been accepted, and under pressure it is stated still further concessions are obtainable for actual business.

## Finished Iron,

In most manufacturing sections of the trade the conditions previously outlined continue without much improvement, with perhaps an exception in the case of South Staffordshire makers of marked bars, who are fairly well engaged, and their price is unaltered at £13 at works. In respect to crown and cheaper irons, the position is without change in any respect, and business is very poor indeed. There is much competition prevailing for orders for crown bars, works outside Staffordshire being very anxious to get other business, and are therefore cutting prices in order to get what little is developing. The figure for crown still varies to a very great extent; outside this area and also in some cases in Staffordshire £9 5s. and £9 10s. per ton is being quoted, but some of the local makers insist upon higher levels, and quote £10 5s. or £10 10s. per ton. Nut and bolt iron is offered round about £9, but there is very little demand, due chiefly to the fact that nut and bolt iron from Continental material is still being offered very much under this. The price of No. 3 iron has appreciated a little, along with other Continental products, and the figure at which this iron is now being quoted is between £6 and £6 5s. per ton delivered the Midlands. It is reported that nut and bolt makers in Darlaston area are somewhat better situated for business, and the orders to the Continent have of late been on an improved scale.

## Steel.

Business in all sections of the steel industry having virtually closed down for the current year, there is no change to record in the general position, with the exception perhaps that there are reports that imported semis are slightly dearer. The upward movement is comparatively small and will not enable British manufacturers to capture the market; but, at any rate, it is in the right direction. The situation continues to be weak, and it is not likely that fresh developments will arise until the New Year. Owing to the German labour trouble, and rumours in other districts, the Continental market has stiffened considerably. There has been a considerable amount of buying, and some of the sellers are now off the market. Soft Thomas billets are now offered at £5 5s. to £5 7s., blooms at £5, and sheet bars at £5 7s. 6d. to £5 8s. 6d. per ton, delivered works in the Midland area. Whether there is a strike or not abroad, it is certain that values will be enhanced. With regard to English semis, no change has taken place, and £6 per ton would be the lowest price for billets and sheet bars. Some Welsh makers are now quoting the same figures. The tinplate market maintains its increased activity, and the tone is better. The works have secured a number of orders and are firmer in their prices.

## Scrap.

Markets for scrap metals for a long time past have been suffering from a lack of business, for which there is no immediate prospect of relief, and at the moment trade is almost entirely suspended. At Middlesbrough, however, a few parcels of heavy cast iron are changing hands on the basis of 62s. 6d. per ton for ordinary quality, and 66s. for machinery quality, but most of the business is for prompt delivery. In Scotland, cast-iron machinery scrap, suitable for foundries and in pieces not exceeding 1 cwt., shows no change at 67s. 6d. per ton; in fact, some small quantities have been disposed of at a little less than this. Heavy ordinary cast iron to the same specification is around 60s. to 61s. 3d. per ton. Old cast-iron railway chairs are quoted around 65s. 6d. to 67s. 6d. per ton, and some odd lots have changed hands at these figures. Light cast-iron scrap is unchanged at 53s. 6d. to 54s. per ton.

## Metals.

**Copper.**—After maintaining for some considerable time a position as the strongest section in the markets for base metals, warrant copper has had a slight relapse, which is not, however, expected to be of permanent importance. The outstanding feature has been the more independent and stronger attitude adopted by the Copper Producers (Inc.), whose selling limit was also raised. It is generally recognised that there is very little fine copper actually available for prompt delivery on this side, while the quantities held in stock are very small.

Official closing prices of standard copper have been as follow:—

*Cash*: Thursday, £59 15s. to £59 17s. 6d.; Friday, £59 11s. 3d. to £59 12s. 6d.; Monday, £59 6s. 3d. to £59 8s. 9d.; Tuesday, £59 11s. 3d. to £59 12s. 6d.; Wednesday, £59 15s. to £59 16s. 3d.

*Three Months*: Thursday, £59 18s. 9d. to £60; Friday, £59 16s. 3d. to £59 17s. 6d.; Monday, £59 11s. 3d. to £59 12s. 6d.; Tuesday, £59 15s. to £59 17s. 6d.; Wednesday, £59 18s. 9d. to £60.

**Tin.**—Some weakening of values has also been marked in standard tin, as contrasted with quotations ruling earlier in the month. Round about December 7, for example, tin was very firm and active, and prices fluctuated upward with an irregular tendency. America then took good quantities of Straits tin afloat and for shipment, which helped the Eastern markets, but London prices have since reacted, chiefly under freer forward offerings and easy American cablegram advices. Eastern terms were reduced, which helped the setback, and the close was rather unsettled at a fairly substantial decline.

Official closing prices of standard tin have been as under:—

*Cash*: Thursday, £267 2s. 6d. to £267 5s.; Friday, £267 7s. 6d. to £267 10s.; Monday, £265 to £265 5s.; Tuesday, £264 5s. to £264 10s.; Wednesday, £266 10s. to £266 15s.

*Three Months*: Thursday, £263 5s. to £263 7s. 6d.; Friday, £263 7s. 6d. to £263 10s.; Monday, £262 to £262 5s.; Tuesday, £261 15s. to £262; Wednesday, £263 2s. 6d. to £263 5s.

**Spelter.**—Little variations of the position in ordinary spelter can be noted, fluctuations in values, although slightly lower in tendency, only amounting to fractional amounts, while consumptive demand is about normal for this period of the year.

The following are the week's prices:—

*Ordinary*: Thursday, £25 6s. 3d.; Friday, £26 3s. 9d.; Monday, £26 5s.; Tuesday, £26 6s. 3d.; Wednesday, £26 3s. 9d.

**Lead.**—In the market for soft foreign pig, the buying movement, which was undoubtedly brought about by the Australian strike, did not last long. On the news that the trouble was over, the market gave way again, actually losing more than the amount of the earlier rise. Consumers have bought fairly freely on most days, but towards the end displayed less interest.

The week's prices are appended:—

*Soft foreign (prompt)*: Thursday, £22 3s. 9d.; Friday, £22 1s. 3d.; Monday, £21 18s. 9d.; Tuesday, £21 17s. 6d.; Wednesday, £21 16s. 3d.

## Personal.

MR. HORACE J. YOUNG, consulting metallurgist and works chemist, of 3, Central Buildings, Westminster, London, S.W.1, has opened a branch of his practice at 497A, Shields Road, Walker Gate, Newcastle-on-Tyne. This consists of laboratories fully equipped for the testing of all materials connected with the engineering, shipping and coal trades. There is a physical testing house for tensile and other usual tests. Mr. H. C. Jay is the chemist in charge of the Walker Gate staff, while Mr. Young will divide his time between London and Newcastle. Mr. Young has strong Tyneside and Wearside connections. For fifteen years as an official of the North-Eastern Marine Engineering Company, his activities covered this firm's works at Wallsend and Sunderland. He took a prominent part in local institutions, and, when president of the Newcastle Branch of the Institute of British Foundrymen, founded the first Junior Section of that Institute.

## Iron and Steel Output in November.

The National Federation of Iron and Steel Manufacturers report that the number of furnaces in blast at the end of November was 155, a net decrease of seven since the beginning of the month, ten furnaces having gone out of operation and three having been put into blast. The production of pig-iron in November amounted to 575,900 tons, compared with 596,300 tons in October and 591,500 tons in September. The November production included 190,500 tons of hematite, 184,300 tons of basic, 152,200 tons of foundry and 27,800 tons of forge pig-iron.

The production of steel ingots and castings amounted to 698,700 tons in November, compared with 699,000 tons in October and 777,000 tons in September.

THE 58TH ANNUAL MEETING of the German Foundry Employers' Federation is to be held at Danzig from June 13 to 15, under the presidency of Dr. Werner.

RUST-RESISTING IRON AND STEEL IN INDIA.—Messrs. Thos. Firth & Company, of Sheffield, are reported to have made arrangements with the Bengal Iron and Steel Company for the manufacture of rust-resisting steel in India. On the other hand, the Tata Iron and Steel Company are negotiating with the American Rolling Mill Company, of Middletown, Ohio, U.S.A., for the acquisition of rights of manufacturing Armco iron in India.

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# STOP THAT AIR LEAK

Which is wasting gas, admitting cold air on to hot linings and generally causing trouble and lowering combustion efficiency,

**BY SEEING THAT ALL THE BRICKWORK JOINTS IN YOUR FURNACES (OF WHATEVER KIND) ARE PROPERLY AND SECURELY SEALED**

# WITH "PYROLYTE"

In all Metallurgical Furnaces there are places where the temperature is insufficient to glaze the jointing materials commonly used, and since these materials do not possess any cold setting properties the joints are generally porous and friable. Joints, even in the cooler parts of furnaces, can be made perfectly

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BY THE USE OF

## "PYROLYTE"

**THE COLD-SETTING REFRACTORY CEMENT**

WHICH IS EQUALLY EFFECTIVE ALSO IN THE HOTTEST ZONES.

***PACKED IN FREE AIR-TIGHT STEEL DRUMS AND MADE SOLELY BY:***

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# WEEKLY PRICE CURRENT.

## COPPER.

| | £ s. d. |
|---|---|
| Standard cash | 59 15 0 |
| Three months | 59 18 9 |
| Electrolytic | 66 5 0 |
| Tough | 64 10 0 |
| Best selected | 65 0 0 |
| Sheets | 90 0 0 |
| India | 75 0 0 |
| Wire bars | 66 15 0 |
| Do. January | 66 12 6 |
| Do. February | 66 12 6 |
| Ingot bars | 66 12 6 |
| H.C. Wire rods | 70 10 0 |
| Off. av. cash, Nov. | 59 17 3 2/11 |
| Do. 3 mths., Nov. | 58 18 0 21/24 |
| Do., Sttlmnt., Nov. | 58 17 3 2/11 |
| Do., Electro, Nov. | 63 19 6 8/11 |
| Do., B.S., Nov. | 63 8 7½ |
| Aver. spot price, copper, Nov. | 58 17 3½ |
| Do., Wire bars, Nov. | 64 3 10½ |
| Solid drawn tubes | 12½d. |
| Brazed tubes | 12½d. |
| Wire | 9½d. |

## BRASS.

| | |
|---|---|
| Solid drawn tubes | 11½d. |
| Brazed tubes | 13½d. |
| Rods, drawn | 10½d. |
| Rods, extd. or rlld. | 7½d. |
| Sheets to 10 w.g. | 10½d. |
| Wire | 9½d. |
| Rolled metal | 9½d. |
| Yellow metal rods | 7½d. |
| Do. 4 × 4 Squares | 8d. |
| Do. 4 × 3 Sheets | 8½d. |

## TIN.

| | £ s. d. |
|---|---|
| Standard cash | 266 10 0 |
| Three months | 263 2 6 |
| English | 265 0 0 |
| Bars | 265 0 0 |
| Straits | 265 0 0 |
| Australian | 269 0 0 |
| Eastern | 265 0 0 |
| Banca | 266 10 0 |
| Off. av. cash, Nov. | 262 13 9 3/11 |
| Do., 3 mths., Nov. | 258 11 9 5/11 |
| Do., Sttlmt., Nov. | 262 13 2 7/11 |
| Aver. spot, Nov. | 262 13 9½ |

## SPELTER.

| | £ s. d. |
|---|---|
| Ordinary | 26 3 9 |
| Remelted | 26 0 0 |
| Hard | 21 0 0 |
| Electro 99.9 | 31 0 0 |
| English | 26 12 6 |
| India | 22 10 0 |
| Zinc dust | 35 0 0 |
| Zinc ashes | 9 0 0 |
| Off. aver., Nov. | 26 2 10 1/11 |
| Aver., spot, Nov. | 26 5 7½ |

## LEAD.

| | £ s. d. |
|---|---|
| Soft foreign ppt. | 21 16 3 |
| English | 23 5 0 |
| Off. average, Nov. | 21 2 0 3/11 |
| Average spot, Nov. | 20 17 9½ |

## ZINC SHEETS, &c.

| | £ s. d. |
|---|---|
| Zinc sheets, English | 35 0 0 |
| Do. V.M. ex whf. | 33 10 0 |
| Rods | 42 0 0 |
| Boiler plates | 30 10 0 |
| Battery plates | 32 0 0 |

## ANTIMONY.

| | £ s. d. |
|---|---|
| Special brands, Eng. | 64 10 0 |
| Chinese | 41 10 0 |
| Crude | 37 0 0 |

## QUICKSILVER.

| | £ s. d. |
|---|---|
| Quicksilver | 23 0 0 |

## FERRO-ALLOYS AND STEEL-MAKING METALS.

| | |
|---|---|
| Ferro-silicon— | |
| 25% | £8 17 6 |
| 45/50% | £12 17 6 |
| 75% | £22 6 0 |
| Ferro-vanadium— | |
| 35/40% | 14/3 lb. va. |
| Ferro-molybdenum— | |
| 70/75% c. free | 5/- lb. |
| Ferro-titanium— | |
| 23/25% carbonless | 11½d |
| Ferro-phosphorus, 20/25% | £17 15 0 |
| Ferro-tungsten— | |
| 80/85% c. fr. | 1/4 lb. |
| Tungsten metal powder— | |
| 98/99% | 1/8 lb. |
| Ferro-chrome— | |
| 2/4% car. | £33 0 0 |
| 4/6% car. | £23 0 0 |
| 6/8% car. | £22 17 6 |
| 8/10% car. | £22 10 0 |
| Ferro-chrome— | |
| Max. 2% car. | £35 17 6 |
| Max. 1% car | £41 12 6 |
| Max. 0.70% car | £52 0 0 |
| 70% carbonless | 1/4 lb. |
| Nickel—99% cubes or pellets | £175 0 0 |
| Ferro-cobalt | 9/3 lb. |
| Aluminium 98/99% | £105 0 0 |
| Metallic chromium— | |
| 96/98% | 2/11 lb. |
| Ferro-manganese (net)— | |
| 76/80% loose | £13 10 0 |
| 76/80% packed | £14 10 0 |
| 76/80% export | £12 0 0 |
| Metallic manganese— | |
| 94/96% carbonless | 1/10 lb. |

Per ton unless otherwise stated.

## HIGH-SPEED TOOL STEEL.

| | |
|---|---|
| Finished bars, 14% tungsten | £0 2 6 |
| Finished bars, 18% tungsten | £0 3 0 |

Per lb. net, d/d buyers' works.

Extras—

| | |
|---|---|
| Rounds and squares, 3 in. and over | 4d. lb. |
| Rounds and squares, under ½ in. to ¼ in. | 3d. lb. |
| Do., under ¼ in. to 3/16 in. | 1/- lb. |
| Flats, ½ in. × ¼ in. to under 1 in. × ⅜ in. | 3d. lb. |
| Do., under ½ in. × ¼ in. | 1/- lb. |
| Bevels of approved sizes and sections | 6d. lb. |

Bars cut to length, 10% extra.

Scrap from high-speed tool steel—

| | |
|---|---|
| Scrap pieces | 3d. |
| Turnings and swarf | 1d. |

Per lb. net, d/d steel makers' works.

## SCRAP.

| | £ s. d. to £ s. d. |
|---|---|
| South Wales— | |
| Hvy. steel | 3 0 0 to 3 3 6 |
| Bundled steel and shrngs. | 2 13 6 to 2 18 6 |
| Mixed iron and steel | 2 14 0 to 2 15 0 |
| Heavy cast iron | 2 17 6 to 2 18 6 |
| Good machinery for foundries | 3 0 0 to 3 2 6 |
| Cleveland— | |
| Heavy steel | 2 17 6 |
| Steel turnings | 2 6 0 |
| Cast iron borings | 2 3 0 |
| Heavy forge | 3 12 6 |
| Bushelled scrap | 3 2 6 |
| Cast-iron scrap | 3 2 6 to 3 6 0 |
| Lancashire— | |
| Cast-iron scrap | 3 5 0 |
| Hvy. wrought | 3 2 6 |
| Steel turnings | 2 2 6 |

London—Merchants' buying prices delivered yard.

| | |
|---|---|
| Copper (clean) | 51 0 0 |
| Brass (clean) | 38 10 0 |
| Lead (less usual draft) | 19 10 0 |
| Tea lead | 16 10 0 |
| Zinc | 17 0 0 |
| New aluminium cuttings | 76 0 0 |
| Braziery copper | 47 0 0 |
| Gunmetal | 48 0 0 |
| Hollow pewter | 170 0 0 |
| Shaped black pewter | 130 0 0 |

## PIG-IRON.

*(f.o.t. unless otherwise stated.)*

| | |
|---|---|
| N.E. Coast— | |
| Foundry No. 1 | 67/6 |
| Foundry No. 3 | 65/- |
| Foundry No. 4 | 64/- |
| Forge No. 4 | 63/6 |
| Hematite No. 1 | 71/6 |
| Hematite M/Nos. | 71/- |
| N.W. Coast— | |
| Hem. M/Nos. d/d Glas. | 84/- |
| ,, d/d Birm. | 89/- to 90/- |
| Midlands— | |
| Staffs. common* | — |
| ,, No. 4 forge | 62/6 |
| ,, No. 3 fdry. | 64/6 to 65/- |
| Shrops. basic | — |
| ,, Cold blast, ord.* | — |
| ,, ,, roll iron* | — |
| * d/d Birmingham. | |
| Northants forge | 54/- |
| ,, fdry. No. 3 | 60/- |
| Derbyshire forge | 60/- |
| ,, fdry. No. 3 | 65/- |
| ,, basic | — |
| Scotland— | |
| Foundry No. 1 | — |
| ,, No. 3 | 71/6 |
| Hem. M/Nos. | 76/- |
| Sheffield (d/d district)— | |
| Derby forge | 65/- |
| ,, fdry. No. 3 | 68/- |
| Lincs. forge | 65/- |
| ,, fdry. No. 3 | 68/- |
| E.C. hematite | 84/6 |
| W.C. hematite | 89/6 |
| Lincs. (at furnaces)— | |
| Forge No. 4 | — |
| Foundry No. 3 | — |
| Basic | — |
| Lancashire (d/d eq. Man.)— | |
| Derby forge | — |
| ,, fdry. No. 3 | 73/6 |
| Northants foundry No. 3 | — |
| Dalzell, No. 3 | 100/- to 102/6 |
| Summerlee, No. 3 | 88/- to 94/- |
| Glengarnock, No. 3 | 88/- to 94/- |
| Gartsherrie, No. 3 | 88/- to 94/- |
| Monkland, No. 3 | 88/- to 94/- |
| Coltness, No. 3 | 88/- to 94/- |
| Shotts, No. 3 | 88/- to 94/- |

## FINISHED IRON AND STEEL.

*Usual District deliveries for iron; delivered consumers' station for steel.*

| Iron— | £ s. d. | £ s. d. |
|---|---|---|
| Bars (cr.) nom. | 9 15 0 | to 10 15 0 |
| Angles | | — |
| Tees to 3 united ins. | | — |
| Nut and bolt iron | | 9 0 0 |
| Hoops | | 12 10 0 |
| Marked bars (Staffs.) f.o.t. | | 13 0 0 |
| Gas strip | | 12 0 0 |
| Bolts and nuts, ¾ in. × 4 in. | | 15 5 0 |
| Steel— | | |
| Ship plates | 8 2 6 | to 8 7 6 |
| Boiler plts. | | 10 10 0 |
| Chequer plts. | | 10 5 0 |
| Angles | | 7 12 6 |
| Tees | | 8 12 6 |
| Joists | | 7 12 6 |
| Rounds and squares, 3 in. to 5½ in. | | 7 15 0 |
| Rounds under 3 in. to ⅜ in. (Untested) | | 8 0 0 and upwards |
| Flats, over 5 in. wide and up | | 9 2 6 |
| Flats, 5 in. to 1½ in. | | 8 2 6 |
| Rails, heavy | 8 2 6 | to 8 7 6 |
| Fishplates | | 12 10 0 |
| Hoops (Staffs.) | | 10 10 0 |
| Black sheets, 24g. | | 10 2 6 |
| Galv. cor. shts., 24g. | | 13 2 6 |
| Galv. fencing wire 8g. plain | | 12 10 0 |
| Billets, soft | £6 0 0 | to 6 10 0 |
| Billets, hard | | 8 2 6 |
| Sheet bars | £5 12 6 | to 5 15 0 |
| Tin bars | £5 12 6 | to 5 15 0 |

## PHOSPHOR BRONZE.

| | Per lb. basis. |
|---|---|
| Strip | 1 2½ |
| Sheet to 10 w.g. | 1 3 |
| Wire | 1 3½ |
| Rods | 1 3 |
| Tubes | 1 8½ |
| Castings | 1 2 |

Delivery 3 cwt. free.
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

## NICKEL SILVER, &c.

| | per lb. |
|---|---|
| Ingots for raising | 9d. to 1/3 |
| Rolled— | |
| To 9 in. wide | 1/3 to 1/9 |
| To 12 in. wide | 1/3½ to 1/9½ |
| To 15 in. wide | 1/3½ to 1/9½ |
| To 18 in. wide | 1/4 to 1/10 |
| To 21 in. wide | 1/4½ to 1/10½ |
| To 25 in. wide | 1/5 to 1/11 |
| Ingots for spoons and forks | 9d. to 1/5½ |
| Ingots rolled to spoon size | 1/- to 1/8½ |
| Wire round— | |
| 3/0 to 10 G. | 1/6½ to 2/1½ |

with extras according to gauge.

## AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

| | Dols. |
|---|---|
| No. 2X foundry, Phila. | 19.76 |
| No. 2 foundry, Valley | 17.25 |
| No. 2 foundry, Birm. | 16.00 |
| Basic | 18.76 |
| Bessemer | 19.51 |
| Malleable | 18.26 |
| Grey forge | 18.51 |
| Ferro-mang. 80% d/d | 100.00 |
| Bess rails, h'y, at mill | 43.00 |
| O.-h. rails, h'y at mill | 43.00 |
| Bess billets | 33.00 |
| O.-h. billets | 33.00 |
| O.-h. sheet bars | 34.00 |
| Wire rods | 40.00 |
| | Cents. |
| Iron bars, Phila. | 2.12 |
| Steel bars | 1.80 |
| Tank plates | 1.80 |
| Beams, etc. | 1.80 |
| Skelp, grooved steel | 1.80 |
| Skelp, sheared steel | 1.80 |
| Steel hoops | 2.20 |
| Sheets, black, No. 24 | 2.75 |
| Sheets, galv., No. 24 | 3.60 |
| Sheets, blue an'l'd., 9 and 10 | 2.10 |
| Wire nails | 2.50 |
| Plain wire | 2.40 |
| Barbed wire, galv. | 3.20 |
| Tinplate, 100 lb. box | $5.25 |

## COKE (at ovens).

| | |
|---|---|
| Welsh foundry | — |
| ,, furnace | — |
| Durham and North. | |
| ,, foundry | — |
| ,, furnace | 13/6 |
| Other Districts, foundry | — |
| ,, ,, furnace (basis) | 12/- |

## TINPLATES.

f.o.b. Bristol Channel ports.

| | | | |
|---|---|---|---|
| I.C. Cokes | 20×14 | box | 18/- |
| ,, | 28×20 | ,, | 36/- |
| ,, | 20×10 | ,, | — |
| ,, | 18¾×14 | ,, | — |
| C.W. | 20×14 | ,, | 17/3 |
| ,, | 28×20 | ,, | — |
| ,, | 20×10 | ,, | — |
| ,, | 18¾×14 | ,, | — |
| Terneplates | 28×20 | — | per box basis f.o.b. |

## SWEDISH IRON.

| | |
|---|---|
| Bars, hammered, | £18 10 0 to 19 0 0 |
| Rolled Ord. | £15 0 0 to £15 10 0 |
| Nail rods | £15 7 6 to £15 15 0 |
| Keg. steel nom. | £33 to £35 |
| Faggot steel nom. | £22 to £25 |
| Blooms, according to quality | £8 to £12 |
| Pig-iron | £5 15 0 to £6 0 0 |

all f.o.b. Gothenburg.

**TUBES AND FITTINGS.**

Up to and incl. 6 in.

| | *Tubes.* | *Fittings.* |
|---|---|---|
| Gas .. .. | 67½% .. | .. 45% |
| Water .. .. | 63¼% .. | .. 40% |
| Steam .. .. | 60% .. | .. 35% |

W.I. 10% extra.

**DAILY FLUCTUATIONS.**

**Standard Copper** (cash).

| | | £ | s. | d. | | |
|---|---|---|---|---|---|---|
| Dec. 15 .. | 59 | 15 | 0 | inc. | 10/- |
| ,, 16 .. | 59 | 11 | 3 | dec. | 3/9 |
| ,, 19 .. | 59 | 6 | 3 | ,, | 5/- |
| ,, 20 .. | 59 | 11 | 3 | inc. | 5/- |
| ,, 21 .. | 59 | 15 | 0 | ,, | 3/9 |

**Electrolytic Copper.**

| | | £ | s. | d. | | |
|---|---|---|---|---|---|---|
| Dec. 15 .. | 66 | 5 | 0 | inc. | 5/- |
| ,, 16 .. | 66 | 7 | 6 | ,, | 2/6 |
| ,, 19 .. | 66 | 5 | 0 | dec. | 2/6 |
| ,, 20 .. | 66 | 5 | 0 | No change | |
| ,, 21 .. | 66 | 5 | 0 | ,, | ,, |

**Standard Tin** (cash).

| | | £ | s. | d. | | |
|---|---|---|---|---|---|---|
| Dec. 15 .. | 267 | 2 | 6 | inc. | 17/6 |
| ,, 16 .. | 267 | 7 | 6 | ,, | 5/- |
| ,, 19 .. | 265 | 0 | 0 | dec. | 47/6 |
| ,, 20 .. | 264 | 5 | 0 | ,, | 15/- |
| ,, 21 .. | 266 | 10 | 0 | inc. | 45/- |

**Tin** (English ingots).

| | | £ | s. | d. | | |
|---|---|---|---|---|---|---|
| Dec. 15 .. | 265 | 15 | 0 | inc. | 25/- |
| ,, 16 .. | 266 | 0 | 0 | ,, | 5/- |
| ,, 19 .. | 263 | 10 | 0 | dec. | 50/- |
| ,, 20 .. | 263 | 0 | 0 | ,, | 10/- |
| ,, 21 .. | 265 | 0 | 0 | inc. | 40/- |

**Zinc Sheets** (English).

| | | £ | s. | d. | | |
|---|---|---|---|---|---|---|
| Dec. 15 .. | 35 | 0 | 0 | No change | |
| ,, 16 .. | 35 | 0 | 0 | ,, | ,, |
| ,, 19 .. | 35 | 0 | 0 | ,, | ,, |
| ,, 20 .. | 35 | 0 | 0 | ,, | ,, |
| ,, 21 .. | 35 | 0 | 0 | ,, | ,, |

**Spelter** (ordinary).

| | | £ | s. | d. | | |
|---|---|---|---|---|---|---|
| Dec. 15 .. | 26 | 6 | 3 | inc. | 2/6 |
| ,, 16 .. | 26 | 3 | 9 | dec. | 2/6 |
| ,, 19 .. | 26 | 5 | 0 | inc. | 1/3 |
| ,, 20 .. | 26 | 6 | 3 | ,, | 1/3 |
| ,, 21 .. | 26 | 3 | 9 | dec. | 2/6 |

**Lead** (English).

| | | £ | s. | d. | | |
|---|---|---|---|---|---|---|
| Dec. 15 .. | 23 | 10 | 0 | inc. | 5/- |
| ,, 16 .. | 23 | 10 | 0 | No change | |
| ,, 19 .. | 23 | 5 | 0 | dec. | 5/- |
| ,, 20 .. | 23 | 5 | 0 | No change | |
| ,, 21 .. | 23 | 5 | 0 | ,, | ,, |

**Exports of Iron Castings in November and the eleven months 1927, compared with November and the eleven months 1926.**

| | November, 1926. | November, 1927. | Eleven months, 1926. | Eleven months, 1927. | November, 1926. | November, 1927. | Eleven months, 1926. | Eleven months, 1927. |
|---|---|---|---|---|---|---|---|---|
| BUILDERS' CASTINGS— | | | | | | | | |
| Stoves, Grates, etc., Cisterns, Baths, etc., and cooking and washing boilers:— | Tons. | Tons. | Tons. | Tons. | £ | £ | £ | £ |
| To Argentine Republic .. .. .. .. .. .. | 86 | 147 | 1,371 | 1,456 | 3,404 | 4,935 | 54,511 | 54,321 |
| ,, British South Africa .. .. .. .. .. .. | 404 | 450 | 4,037 | 2,862 | 12,954 | 15,873 | 136,144 | 103,205 |
| ,, ,, East Indies .. .. .. .. .. .. | 149 | 224 | 1,638 | 1,660 | 6,844 | 11,741 | 72,569 | 79,772 |
| ,, Australia .. .. .. .. .. .. | 81 | 80 | 774 | 853 | 4,867 | 4,487 | 44,322 | 49,300 |
| ,, New Zealand .. .. .. .. .. .. | 235 | 244 | 2,282 | 1,901 | 13,603 | 12,832 | 113,627 | 97,556 |
| ,, Other countries .. .. .. .. .. .. | 880 | 1,112 | 7,836 | 7,540 | 45,778 | 47,970 | 383,889 | 369,613 |
| Total .. .. .. .. .. .. | 1,835 | 2,257 | 17,938 | 16,272 | 87,450 | 97,838 | 805,062 | 753,767 |
| PIPES AND FITTINGS—CAST— | | | | | | | | |
| To Argentine Republic .. .. .. .. .. .. | 589 | 913 | 7,660 | 8,751 | 6,540 | 10,695 | 92,946 | 97,374 |
| ,, British South Africa .. .. .. .. .. .. | 296 | 2,362 | 6,681 | 13,898 | 5,954 | 22,132 | 95,140 | 152,316 |
| ,, ,, India .. .. .. .. .. .. | 240 | 643 | 7,166 | 6,447 | 3,568 | 8,584 | 93,252 | 98,245 |
| ,, Straits Settlements and Malay States .. .. .. | 421 | 1,683 | 14,247 | 14,092 | 4,873 | 16,769 | 124,492 | 138,496 |
| ,, Ceylon .. .. .. .. .. .. .. .. | 88 | 46 | 1,817 | 1,231 | 1,467 | 577 | 21,655 | 14,453 |
| ,, Australia .. .. .. .. .. .. .. | 65 | 1,166 | 3,442 | 8,880 | 1,549 | 12,139 | 50,566 | 104,984 |
| ,, Other countries .. .. .. .. .. .. | 2,203 | 6,064 | 41,490 | 57,906 | 38,589 | 83,253 | 597,731 | 757,037 |
| Total .. .. .. .. .. .. | 3,902 | 12,877 | 82,503 | 111,205 | 62,540 | 154,149 | 1,075,782 | 1,362,905 |
| HOLLOW-WARE— | | | | | | | | |
| Cast, not Enamelled, and Cast, Tinned .. .. .. | 500 | 522 | 6,081 | 4,430 | 19,363 | 21,039 | 215,318 | 173,984 |
| ,, Enamelled .. .. .. .. .. .. .. | 84 | 83 | 900 | 662 | 9,572 | 9,104 | 97,587 | 69,174 |
| CASTINGS, in the rough— | | | | | | | | |
| Iron .. .. .. .. .. .. .. .. | 48 | 225 | 1,205 | 1,220 | 2,330 | 5,643 | 36,038 | 41,901 |
| Steel .. .. .. .. .. .. .. .. | 59 | 68 | 633 | 924 | 2,909 | 3,042 | 21,079 | 42,858 |


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THE PROPRIETORS of the Patent No. 137,574, for "Improvements in Steel-Smelting Furnaces," are desirous of entering into arrangements by way of licence and otherwise on reasonable terms for purpose of exploiting same and ensuring its full development and practical working in this country.—All communications should be addressed in first instance to HASELTINE, LAKE & Co., Chartered Patent Agents, 28, Southampton Buildings, Chancery Lane, London, W.C.2.

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6.—Steel Plates and Sheets.
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8.—Steel Castings (Wheel Centres).
9.— do. (Miscellaneous).
11.—Chain and Iron for Chain Manufacture.
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13.—Cold-Drawn Steel Tubes.
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Tenders addressed to the undersigned and marked outside "Tender for Iron and Steel," will be received not later than 10.0 a.m. on TUESDAY, January 10th, 1928.

The Directors do not bind themselves to accept the lowest or any Tender.

F. R. E. DAVIS, Secy.

Paddington Station, London, W.2.
19th December, 1927.

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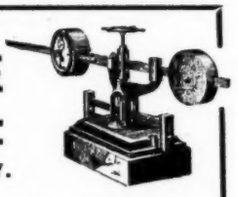

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